Vol. 15, No. 2

JUL 2 1923

Medical Lib.

June, 1923

PARASITOLOGY

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VOLUME XV JUNE, 1923 No. 2

A COLLECTION OF NEMATODE PARASITES FROM ZANZIBAR.

BY C. L. BOULENGER, M.A., D.Sc.

(With 5 Text-figures.)

FOR the opportunity of studying this collection of round-worms from Zanzibar I am greatly indebted to Mr W. Mansfield-Aders, Economic Biologist to the Zanzibar Government.

A small collection from this locality, consisting of Sclerostomes obtained from the donkey, was described by me in 1920, the present material contains species collected from a number of both domesticated and wild animals on the island.

Altogether sixteen species have been identified from Mr Mansfield-Aders' collection, the majority are well-known round-worms having a world-wide distribution as parasites of domesticated animals, and are listed only on account of the locality, a few, however, especially certain forms from non-domesticated hosts, are of greater interest and are discussed more fully.

ASCARIDAE.

1. Belascaris cati (Schrank, 1788).

From the stomach and intestine of the domestic cat.

2. Belascaris marginata (Rud., 1802).

From the small intestine of the dog.

3. Contracaecum sp.

A single immature female obtained from the stomach of a night-heron, *Nycticorax nycticorax*, it is most probably *C. rosarium* (Connal, 1912) but an exact determination is impossible.

OXYURIDAE.

4. Oxyuris equi (Schrank, 1788).

Numerous specimens from the caecum of the donkey.

HETERAKIDAE.

5. Heterakis dahomensis Gendre, 1911.

(*H. spumosa* Hall, 1916, *pro parte*.)

A number of specimens from the African rat, *Cricetomys gambianus*; this species was first described by Gendre (1911) from the same host in Dahomey.

Hall in his monograph of the Nematodes of Rodents (1916) considers *H. dahomensis* as a synonym of *H. spumosa* Schneider, the common form from European rats and mice, in his discussion he says: "Gendre's figures and description seem to warrant this in spite of the fact that there are some discrepancies between his description and that commonly given or given in the above notes. His specimens measure a little larger than is usual, but still

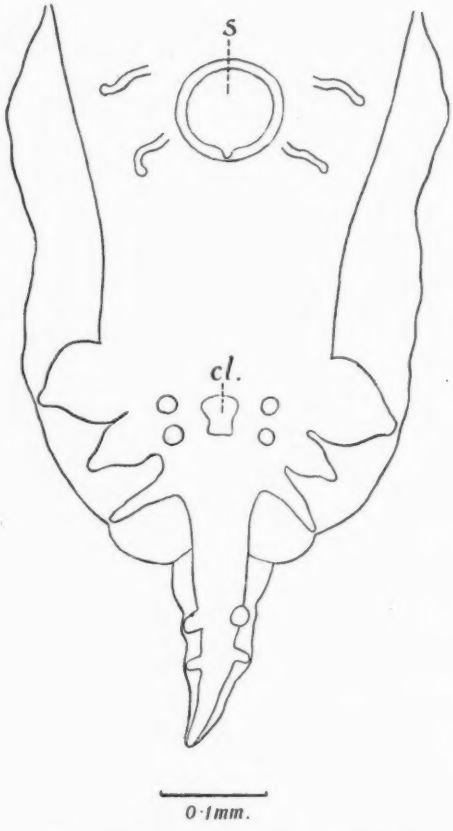

Fig. 1. *Heterakis dahomensis.* Ventral view of tail of male. *cl.* cloacal opening; *s.* ventral sucker.

within the reasonable limit of variation. He only figures two papillae on the tail proper, but that may easily be due to errors of observation or even anomalies. The spicule measurement given by him (400 μ) is longer than I find it."

The specimens from Zanzibar make it quite clear that the presence of two instead of three pairs of papillae on the posterior tail region is a constant

character of the form from *Cricetomys gambianus* and that Gendre's species must stand; Gedoelst (1916) is evidently of the same opinion since he lists *H. dahomensis* from a rat (species not determined) in the Belgian Congo without comment.

Hall's specific diagnosis of *H. spumosa* is apparently a composite one, based on the two species which are certainly very closely allied, I therefore give a short account of the principal measurements of *H. dahomensis* based on the Zanzibar specimens:

Head 0·08 to 0·09 mm. in diameter. Length of oesophagus, including the oesophageal bulb, 0·85 to 0·95 mm. A lateral cuticular membrane originates on each side about 0·08 mm. from the anterior extremity, it attains its maximum breadth of 0·045 mm. at the level of the posterior part of the oesophagus, behind this it narrows slightly but extends to the anal region. A pair of cervical papillae is situated about 0·4 mm. from the anterior extremity. The nerve-ring is 0·3 mm. from the head end.

Male 7·5 to 9·7 mm. long, with a maximum thickness of about 0·35 mm.

The bursa originates 0·7 to 0·83 mm. from the tip of the tail, it has much the same structure as that of *H. spumosa*, appearing three-lobed in a lateral view. As in that species there are four pairs of ventral papillae in the caudal region, of these the anterior two pairs are stalked, the posterior sessile; the bursa is sustained by five pairs of laterally situated papillae instead of six as in *H. spumosa*.

The sucker is situated about 0·53 mm. from the posterior extremity, the distance from the cloacal aperture to the tip of the tail is 0·3 to 0·32 mm.

The spicules are equal and slender, measuring 0·32 to 0·37 mm. in length.

Female 9·5 to 13 mm. in length with a maximum thickness of about 0·4 mm. The anus is 0·9 to 1 mm. from the posterior extremity.

The vulva is a slit with prominent lips situated near the middle of the body, usually a little anterior to it, thus in a specimen 10·8 mm. long the opening is 5·3 mm. from the head end, in one 12·7 mm. long it is 6 mm. from this point (in *H. spumosa*, according to Hall, the vulva is slightly posterior to the middle of the body). In the neighbourhood of the vulva, both anterior and posterior to the opening, in mature specimens there are a number (1–5) of cuticular prominences.

Eggs 0·05 to 0·062 mm. by 0·04 to 0·05 mm. wide.

6. **Ascaridia lineata** (Schneider, 1866).

(*A. hamia* Lane, 1914.)

A single, male specimen from the stomach of a chicken.

This species evidently has a wide distribution in tropical and sub-tropical countries, it is now known from Brazil (Schneider, 1866 and Travassos, 1913), Turkestan (v. Linstow, 1883), Belgian Congo (Gedoelst, 1916) and Zanzibar. I also consider the form described by Clayton Lane (1914) from fowls in India

as *A. hamia* to be identical with Schneider's species, the very slight differences in the arrangement of the male caudal papillae being within the limit of variation in species of this genus. Lane seems to have been unaware of v. Linstow's record of this worm, since it is not mentioned in his list of species of *Ascaridia* from the East.

As shown in Text-fig. 2, the specimen from Zanzibar agrees with Schneider's type specimen in that the second lateral caudal papilla (*l.p.*^{2}) is directed

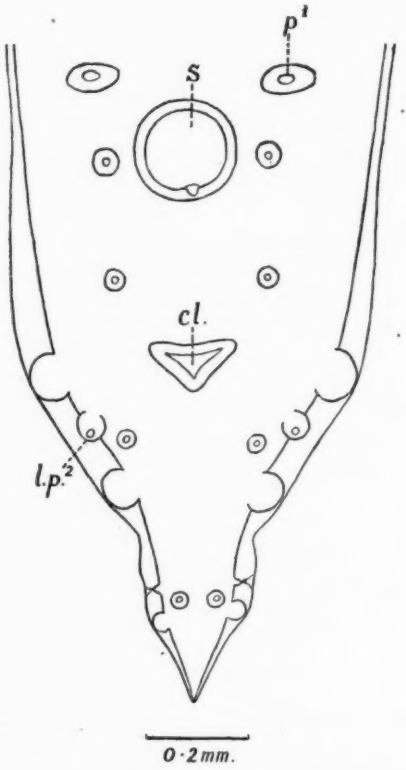

Fig. 2. *Ascaridia lineata*. Ventral view of tail of male. *cl.* cloacal opening; *l.p.*^{2} second lateral papilla; *p.*^{1} first ventral papilla; *s.* ventral sucker.

towards the ventral surface; Lane's figure as well as v. Linstow's shows this papilla projecting laterally. On the other hand the specimen before me shows the characteristic transverse elongation of the first ventral papilla (*p.*^{1}) figured by v. Linstow, a point not noted by Schneider or Lane. These slight discrepancies are no doubt due to individual variation or to differences in the preservation of the specimens.

7. Subulura otolicni (Van Beneden, 1890).

(*S. loveridgei* Baylis, 1920.)

Numerous specimens from the caecum of *Galago garnetti*.

For the first complete description of this form we are indebted to Gedoelst (1916) who referred to Van Beneden's species some worms obtained in the Belgian Congo from *Galago mossambicus*.

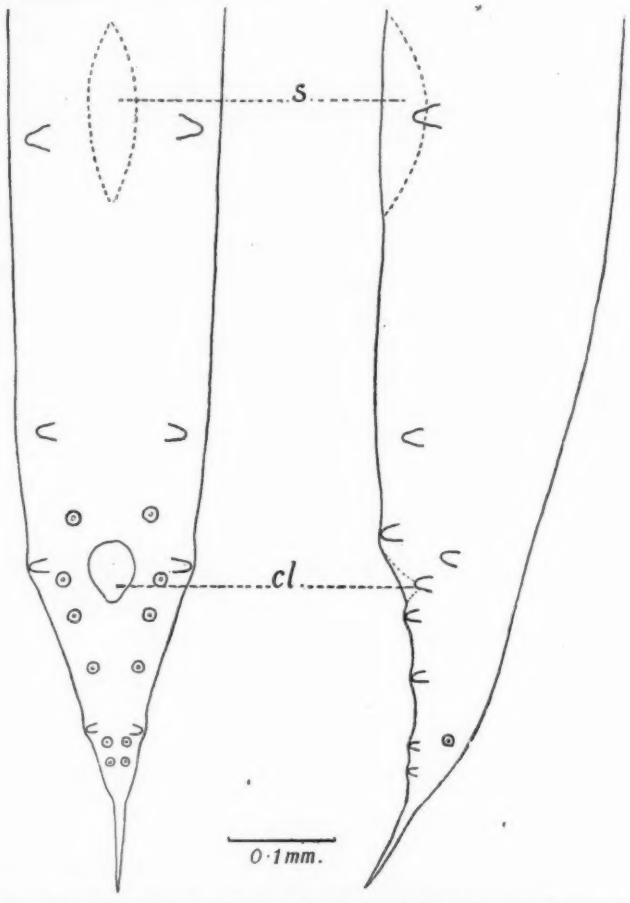

Fig. 3. *Subulura otolicni*. Ventral and lateral views of posterior extremity of male. *cl.* cloacal opening; *s.* ventral sucker.

The specimens sent by Mr Mansfield-Aders differ from previously described examples in reaching a considerably larger size, the males measuring up to 12 mm., the females up to 27·5 mm. in length. I have tentatively ascribed

to this species the form from E. Africa described by Baylis (1920) as *S. loveridgei*, the host of this worm was thought to be a mongoose, but its identification was doubtful owing to the loss of the collector's label. The great difference in size between *S. otolicni* and *S. loveridgei* is completely bridged by the Zanzibar specimens and I can find no constant character to separate the two species, comparison of my measurements and figures of the male tail with those given by Gedoelst and Baylis will show that the arrangement of the caudal papillae and other structures in this region are practically identical in the forms from the three localities.

The measurements of the Zanzibar worms are as follows:

Head 0·13 to 0·18 mm. in diameter. Buccal cavity 0·055 mm. long with a maximum breadth of 0·065 mm. Oesophagus (including the posterior bulb) 1·25 to 2 mm. in length. Nerve-ring 0·25 to 0·35 mm., excretory pore 0·5–0·55 mm. from the anterior extremity of the body.

Male 7·2 to 12 mm. in length with a maximum breadth of 0·3 to 0·4 mm. Tail (i.e. the distance from the cloacal opening to the posterior extremity of the body) 0·22 to 0·28 mm. long. Sucker 0·6 to 0·7 mm. from the tip of the tail. Spicules 1·6 mm., gubernaculum 0·2 mm. in length.

Female 12 to 27·5 mm. in length, with a maximum breadth of 0·4 to 0·5 mm. Anus 1·1 to 1·8 mm. from the posterior extremity. Vulva in front of the middle of the body, in the largest specimen (27·5 mm. in length) it is 10·3 mm. from the anterior extremity.

Eggs 0·06 to 0·075 long by 0·04 to 0·052 wide.

STRONGYLIDAE.

8. **Strongylus vulgaris** (Looss, 1900).

9. **Strongylus edentatus** (Looss, 1900).

From the caecum of the donkey. These two species have already been recorded by me (1920) from the same host in Zanzibar.

10. **Oesophagostomum columbianum** (Curtice, 1890).

From the caecum of sheep and goats.

11. **Oesophagostomum dentatum** (Rud., 1803).

From the caecum of the domestic pig.

12. **Haemonchus contortus** (Rud., 1803).

From the fourth stomach (abomasum) of sheep.

SPIRURIDAE.

13. **Physaloptera praeputialis** v. Linst., 1889.

In the material from Zanzibar are a number of specimens of a Physalopterid obtained from the stomach of the domestic cat and the leopard (*Felis pardus*) which, in spite of some discrepancies, I take to belong to von Linstow's species. *Physaloptera praeputialis* was originally described from *Felis catus*, but has

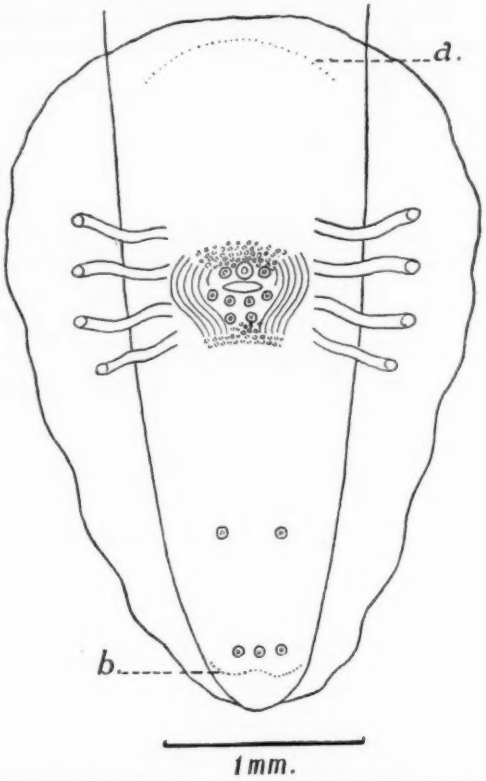

Fig. 4. *Physaloptera praeputialis.* Ventral view of male tail after removal of the prepuce-like cuticular sheath. The cuticular projections and ridges are shown only in the neighbourhood of the cloaca, the dotted lines *a.* and *b.* show the limits of the sculptured area.

also been recorded from the Malay tiger, this is, I believe, the first record of the worm from the leopard; I have also some notes made on the same species obtained from a fishing cat (*Felis viverrina*) which died in the London Zoological Gardens.

The worms studied by me reach a considerably larger size than the type specimens, von Linstow's measurements were ♀ 30 mm., ♂ 21 mm. long; the Zanzibar specimens have a length of: ♀♀ 30 to 55 mm., ♂♂ 27 to 35 mm.

Female. In the female worms from all three hosts examined by me the vulva lies somewhat further back on the body than is stated by von Linstow; the latter gives the female genital opening as 8 mm. from the anterior extremity in a specimen 30 mm. long, in a worm of the same total length I find the vulva to be situated 13·5 mm. from the head end, *i.e.* just in front of the middle of the body. In a specimen 44 mm. long the vulva is 18·8 mm., in one 55 mm. long 20·2 mm. from the anterior extremity. The point is, however, not one of great importance, since in some other species (*e.g. P. getula* Seur.) the position of the vulva has been shown to vary considerably in different individuals (cf. Seurat, 1917, p. 216).

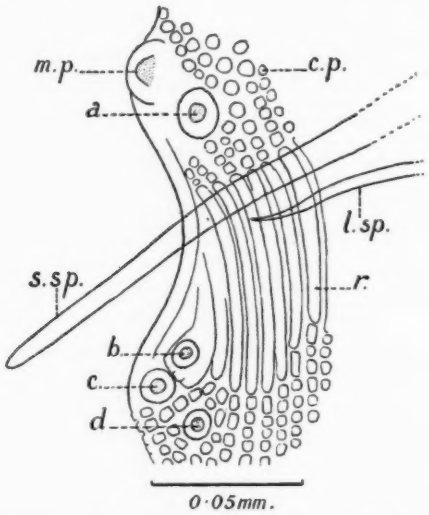

Fig. 5. *Physaloptera praeputialis.* Lateral view of cloacal region. *a.* preanal paired papilla; *b. c. d.* postanal paired papillae; *c.p.* cuticular projections; *m.p.* median papilla; *r.* cuticular ridges; *l.sp.* long spicule; *s.sp.* short spicule.

In a number of females the region of the vulva is surrounded by a clitellum-like ring of brown cement, probably secreted by the cement-glands of the males during copulation.

Male. In the male caudal region von Linstow described 10 ventral papillae in addition to the four pairs of stalked lateral papillae supporting the bursa, he was, however, only able to examine a single specimen of this sex and himself confessed that his interpretation of the structure of the male tail might prove incorrect. In all the specimens examined by me there are 14 sessile caudal papillae (Text-fig. 4), of these one large median papilla and a pair of smaller ones are preanal in position, the remainder postanal. Of the postanal papillae three pairs are situated close behind the cloacal aperture, two pairs and a posterior median papilla on the tail proper.

The ventral surface of the body in the region of the bursa bears numerous small, flattened and scale-like projections of the cuticle, in the area immediately lateral to the cloacal opening a number of these cuticular projections become fused to form longitudinal ridges (Text-fig. 5); the number and arrangement of the ridges varies somewhat in different individuals.

The spicules were not described by von Linstow, they are very unequal, measuring 1·15 mm. and 0·6 mm. respectively. The long spicule is slender and ends in a fine, slightly curved point (Text-fig. 5), the short spicule is stouter and has a straight, rather blunt termination.

FILARIIDAE.

14. Setaria equina (Abildg., 1789).

From the peritoneum of the donkey.

15. Setaria labiatopapillosa (Aless., 1838).

A single specimen, labelled "heart of Ox."

TRICHURIDAE.

16. Trichuris ovis (Abildg., 1795).

From the large intestine of sheep.

REFERENCES.

BAYLIS, H. A. (1920). Notes on some Parasitic Worms from East Africa. *Ann. Mag. Nat. Hist.* VI. 286.

BOULENGER, C. L. (1920). Sclerostomes of the Donkey in Zanzibar and East Africa. *Parasitology*, XII. 27–32.

GEDOELST, L. (1916). Notes sur la Faune parasitaire du Congo Belge. *Rev. Zool. Afric.* V. 1–90.

GENDRE, E. (1911). Sur quelques Espèces d'*Heterakis* du Dahomey. *Proc.-verb. soc. linn. Bordeaux*, LXV. 68–78.

HALL, M. C. (1916). Nematode Parasites of Mammals of the Orders Rodentia, Lagomorpha and Hyracoidea. *Proc. U.S. Nat. Mus.* L. 45.

HARRISON, A. J. and HALL, I. W. (1909). Fatal Enteritis in a Tiger caused by *Physaloptera praeputialis*. *Parasitology*, II. 29–31.

LANE, C. (1914). Suckered Round-Worms from India and Ceylon. *Ind. J. Med. Res.* II. 662.

LINSTOW, O. VON (1883). Nematoden, Trematoden und Acanthocephalen, gesammelt von Prof. Fedtschenko in Turkestan. *Arch. f. Naturg. Berl.* XLIX. 292.

—— (1889). Helminthologisches. *Arch. f. Naturg. Berl.* 1888, v. 235–246.

SCHNEIDER, A. (1866). *Monographie der Nematoden*, Berlin, 70.

SEURAT, L.-G. (1917). Physaloptères des Mammifères du Nord-Africain. *C. r. Soc. Biol.* LXXX. 216.

TRAVASSOS, L. (1913). Ueber die brasilianischen Arten der Subfamilie *Heterakinae* Railliet u. Henry. *Mem. Inst. Osw. Cruz Rio de Janeiro*, v. 293.

VAN BENEDEN, P. J. (1890). Un Nématode nouveau d'un Galago de la Côte de Guinée. *Bull. Acad. roy. Sc. Belgique*, XIX. 389.

EXPERIMENTS ON THE DISINFECTION OF SPERM IN MAMMALS, ESPECIALLY IN RELATION TO DOURINE IN HORSES.

By E. IWANOW,

Director of the Central Experimental Station for the Breeding of Domestic Animals, Moscow.

The problem of sperm disinfection in mammals is not only interesting from the biological standpoint. It is of practical value especially in the horse-breeding industry.

Not infrequently, a valuable stallion is removed from the stud owing to some of the mares covered by him being found to suffer from Dourine, and there being no guarantee that the stallion is uninfective, for some breeding stallions, whilst they appear to recover from Dourine, may become infective again owing to recrudescence of the disease.

The productive power of such animals may be utilized, however, by employing an agent capable (*a*) of killing, or at least depriving, *Trypanosoma equiperdum* of its infective properties and virulence whilst being (*b*) harmless to the horse's spermatozoa.

In studying mammalian spermatozoa, I found them to be comparatively resistant to chemical and physical agents[1]. My results agree with those obtained by other authors who have experimented with the sexual elements of various species of animals (Hertwig, Herbst, Hodge, Nice, Stockard, Papanicolaon, Stevens)[2].

I. Experiments upon Spermatozoa with Physical agents.

My numerous experiments with *radium* and *ultra-violet rays* gave bad results: radium exerted a very harmful effect upon mammalian spermatozoa, those of rabbits, mice, guinea-pigs and dogs may retain an energetic progressive motility, but they lose their fertilizing power. The results of artificial fertilization with radium-treated sperm were invariably negative, whereas the control sperm produced conception.

[1] Whereas my work on the influence of alcohol on spermatozoa has been published (*v. infra*), that on the influence of radium and ultra-violet rays has not hitherto appeared, the records relating thereto having probably perished in Ascania-Nova (S. Russia). See E. Iwanow, "Action de l'alcool sur les spermatozoïdes des mammifères. Expériences sur la fécondation des mammifères avec le sperme mélangé d'alcool," *C. R. Soc. Biol.* LXXIX. 480–484.

[2] Hertwig (1918), "Keimschädigungen durch physikalische und chemische Eingriffe," *Zeitschr. f. indukt. Abstamm. u. Vererb.* XIX. 1–2.

Experiments with ultra-violet rays (mercury arc) showed that several minutes' exposure to strong rays left mammalian spermatozoa still potent —they produced conception resulting in the birth of normal offspring. Such results were only obtained, however, when a considerable amount of sperm was used and the rays did not penetrate through the whole layer of fluid. Obviously under such conditions infective agents would survive as well as the uninjured spermatozoa.

II. Experiments with Chemical Agents.

The foregoing results led me to abandon physical in favour of chemical agents, viz. alcohol, atoxyl, salvarsan (arsol, arsominol) and neo-salvarsan.

1. *Alcohol: Its effect on Spermatozoa and* T. equiperdum.

My earlier experiments having shown that it was possible to produce a normally developed and vigorous offspring by fertilization with sperm containing up to 10 per cent. alcohol, I proceeded to test the influence of alcohol upon *T. equiperdum*[1]. It was found that the latter, when kept in normal salt solution containing 10 per cent. alcohol, retain an energetic progressive motility during one hour. In the presence of 20–25 per cent. alcohol some mobile trypanosomes can still be found after 80 minutes. Therefore *T. equiperdum* is more resistant to alcohol than are mammalian spermatozoa, which cease moving almost instantly in a medium containing above 20 per cent. of alcohol.

Experiments wherein mice were inoculated with *T. equiperdum*, previously kept for 30–60 minutes in 10 per cent. alcohol, have shown that the virulence of the trypanosomes is not diminished. Mice inoculated subcutaneously with blood containing *T. equiperdum* that had been acted upon by 10 per cent. alcohol[2] showed trypanosomes in their blood on the next day and succumbed after three days, whereas in the control mouse the parasites appeared in the blood after four days, and death took place seven days after inoculation. This result does not, in my opinion, point to an increase in the virulence of *T. equiperdum*, because the dose of alcohol introduced with the inoculum sufficed to lower the resistance of the mouse.

2. *Atoxyl: Its effect on* T. equiperdum.

These experiments showed that *T. equiperdum* can very well tolerate solutions of 8–10 per cent. atoxyl and remain infective.

The combination of alcohol and atoxyl (5 per cent. alcohol plus 5 per cent. atoxyl in saline) slightly weakens but does not deprive *T. equiperdum* of its

[1] As an infective agent I selected *T. equiperdum*, which escapes with the blood of stallions suffering from dourine when lesions are produced in coitus, the parasites consequently infecting the sperm. See my paper, "A contribution to the Biology of *Trypanosoma equiperdum*," *Parasitology*, XIV. 315.

[2] The mice received about 0·3–0·5 c.c. of salt solution containing 10 per cent. alcohol + 5 drops of infective blood per 1 c.c. (See Note to Protocols of Experiments (p. 125) regarding this rough mode of dosage.)

virulence for, after exposure of the trypanosomes to these reagents, when they were centrifuged and washed in pure saline, they appeared in the blood of inoculated mice after five days, death taking place ten days after inoculation, whereas in control mice the parasites appeared in the blood after four days and death took place after seven days. That the spermatozoa of dogs and rabbits may endure doses of 0·5 per cent. atoxyl when the sperm and atoxyl are introduced together into the genital tract of the female, is shown by an experiment wherein one out of three female rabbits produced offspring after fertilization with the atoxylized sperm. If, however, 5 per cent. atoxyl is mixed with the spermatozoa, the energy of their activity is reduced immediately, only oscillatory movements remaining, and these gradually cease after 30–40 minutes.

Therefore atoxyl was obviously unsuitable for my purposes.

3. *Salvarsan (arsol, arsaminol) and Neo-salvarsan: Their effects on* T. equiperdum.

Salvarsan and Neo-salvarsan appear to act in a similar manner on *T. equiperdum*. Saline dilutions of 1:10,000 of each of these reagents failed to kill the trypanosomes after 15 minutes, but deprived them of their infectivity, this being probably due to multiplication being inhibited. Similar results were obtained by Castelli with *T. brucei*.

Neo-salvarsan gave similar results after five or ten minutes. Arsaminol gave a like result in dilutions of 1:20,000, but already when diluted to 1:25,000, the effect was diminished; the appearance of the parasites in the blood of inoculated animals was considerably retarded, as compared with the controls (the trypanosomes appeared on the 13th instead of the 4th day), and death took place much later (on the 18th, instead of the 6th day). Dilutions of 1:50,000 and 1:100,000 had no influence on the course of the disease, the trypanosomes appearing in the mouse's blood and death being only retarded by one day.

4. *Salvarsan (arsol, arsaminol): Effects on Spermatozoa.*

Solutions of the above named preparations acted upon spermatozoa in the following manner:

Arsol added to dog's sperm in concentrations up to 1:1000 does not apparently affect the motility of the spermatozoa after 30 minutes, but after one hour motility is reduced when compared to that in controls, the relative progressive motility of the arsol-treated to that of the untreated (control) spermatozoa being expressed by the ratio 4:5, whilst after three hours the difference is sharply marked, the ratio being as 2:4 (most of the spermatozoa showing energetic oscillatory movements). With *rabbits'* spermatozoa taken from the epididymis and suspended in saline containing arsol 2:10,000, even after two hours the motility stood at 4:5; only after seven hours did the motility fall to 2:5 (the spermatozoa mostly showing energetic oscillatory movements).

With *horse's* spermatozoa, subjected to the influence of arsol 1:10,000, it is impossible for some time to detect any difference in the motility of the arsol-treated and untreated (control) spermatozoa; even after two hours the difference is hardly noticeable. Arsol dilutions of 1:10,000 exert no visible influence upon the motility of horse, dog and rabbit spermatozoa within thirty minutes.

Experiments on artificial insemination in rabbits with rabbit spermatozoa taken from the epididymis and mixed with saline containing *arsol* and *arsaminol* 1:5000 and 1:10,000 gave the following results:

(*a*) Two females were inseminated *per vaginam* with sperm in saline containing arsol 1:5,000, ten minutes after mixture. No conception took place.

(*b*) Ten females were similarly inseminated with sperm in saline containing arsaminol 1:10,000, twenty minutes after mixture. Conception took place in five, whilst five remained sterile. No ill-effects were observed in the case of the rabbits that became pregnant and they gave birth to normal progeny.

SOME PROTOCOLS OF EXPERIMENTS

With Arsol, Neo-salvarsan and Arsaminol upon Trypanosoma equiperdum.

NOTE. The various drugs used were dissolved in 0·85 per cent. physiological salt solution in the strength of 1:10,000, etc., as entered in the protocols. The trypanosomes were obtained from the blood of infected mice expressed between the fingers from the animal's tail, five "drops" of blood[1], thus collected, being added per 1 c.c. in each case, to the solution above mentioned.

After the *mixture* of infective blood and drug solution in saline had stood for a variable time, it was centrifuged and the deposit washed in saline solution, this process being repeated twice. Finally, the trypanosomes were suspended in saline and (*a*) injected subcutaneously into mice or (*b*) introduced *per vaginam* into rabbits whose labia minora had been abraded to facilitate infection, the trypanosomes being actively motile in all cases when inoculated. Control animals received, from the same source as the test animals, similar amounts of infective blood which had not been subjected to the influence of the drug.

Experiment I.

2 *Test Mice* injected with trypanosomes treated with *Arsol* 1:10,000. Mixture stood 15 minutes.

Result negative. No tryps found in blood on days 1–20. Mice under observation for 40 days.

1 *Control Mouse.*

Result positive. Tryps found on days 6, 7, 8. Death on day 9.

Experiment II.

3 *Test Mice* injected with 0·3 c.c. suspension of tryps treated with *Neo-salvarsan* 1:10,000. Mixtures stood 5, 10, and 15 minutes respectively.

Result negative. No tryps were found in blood during 3 weeks. Mice under observation for 3 months.

1 *Control Mouse.*

Result positive. Tryps found on days 4, 5. Death on day 6.

[1] The dosage by "drops" was very rough owing to the varying size of the drops expressed from the mouse's tail, the blood being collected in a fine pipette.

Experiment III.

3 *Test Mice* injected with 0·3 c.c. suspension of tryps with *Arsaminol* 1:25,000; 1:50,000; 1:100,000 respectively. Mixture stood 30 minutes.

Result (*a*) positive (with 1:25,000). Tryps found on days 13–17. Death (much delayed) on day 18.

(*b*) positive (with 1:50,000). Tryps found on days 4–6. Death on day 7.

(*c*) positive (with 1:100,000). Tryps found on days 5–6. Death on day 7.

1 *Control Mouse.*

Result positive. Tryps found on days 4–5. Death on day 6.

Experiment IV.

3 *Test rabbits* received *per vaginam* each 1 c.c. suspension of tryps, treated with *Arsol* 1:20,000. Mixture stood 30 minutes.

Result negative. Remained under observation for 3 months. Blood of one of the rabbits inoculated into a mouse with negative result after 30 days.

1 *Control rabbit.*

Result positive. Died after 43 days with characteristic symptoms. Its blood taken 30 days after inoculation infected a mouse which showed tryps on day 8 and died on day 10.

Conclusions.

The results herein recorded show that it is possible to disinfect sperm without diminishing its potency. They therefore establish an important principle which should serve as a guide to further investigations that may well lead to discoveries of theoretical and practical significance.

Our investigations find direct application in the horse-breeding industry. They show that Salvarsan and Neo-salvarsan in 1:10,000 dilution, render *Trypanosoma equiperdum* uninfective in 15 minutes, whereas they exert no appreciable effect on spermatozoa in two hours.

As a means of preventing infection with Dourine amongst stallions in regions where this disease is prevalent, we recommend, prior to coitus being allowed, that the vagina of mares be washed with physiological salt solution containing salvarsan (Arsol, Arsaminol) or Neo-salvarsan 1:10,000 and that the penis of stallions be washed with an aqueous solution of the same strength after coitus[1].

For the eradication of the disease in localities where Dourine is widely distributed, it is useful to substitute the natural covering of mares by artificial insemination[2], having recourse in any doubtful case to disinfection of the sperm by adding to the latter a solution of salvarsan or neo-salvarsan in the above-named concentration. As a prophylactic measure it may be useful to employ an ointment containing salvarsan 1:10,000. The ointment should not contain mercury compounds to which spermatozoa are very sensitive. The anointing

[1] A preparation named "189," manufactured in France, is being recommended as a specific remedy against trypanosomes; it may prove better suited for disinfecting the sperm than the drugs hitherto tested.

[2] E. Iwanow (1907), "Artificial Insemination in Mammals," *Arch. Biol. Sci. St Petersburg.* (In Russian.)

of the stallion's penis will serve to lessen friction during coitus, thereby decreasing the extent of the abrasions which serve as ports of entry for infection. Moreover, the ointment may lower the infectivity of the trypanosomes with which it comes in contact.

The observation that *T. equiperdum* lose their infective power under the influence of weak solutions of salvarsan and neo-salvarsan, without losing their vitality, is of interest. The peculiar behaviour of the trypanosomes in this respect suggests that it may afford a means of producing active immunization against Dourine.

ON *ILISHA PARTHENOGENETICA*, SOUTHWELL AND BAINI PRASHAD, 1918, FROM THE PYLORIC CAECA OF A FISH, *HILSA ILISHA* (HAM. BUCH.), AND A COMPARISON WITH OTHER PLEROCERCOID LARVAE OF CESTODES.

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(With Plate V, containing 18 figures.)

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I. Preliminary Remarks and Mode of Occurrence.

In 1918 Southwell and Baini Prashad[1] published a description of an unsegmented Cestode parasite—*Ilisha parthenogenetica*—which they discovered in the "mesentery" of the common edible Indian Shad, *Hilsa ilisha*. This minute parasite, according to these authors, "appears to be of very great systematic importance, and...further reproduces itself in a manner not before known amongst the Cestoda." In justification of these general remarks, they make, among others, the following statements: (1) the parasite, though of the well-known *Piestocystis* larva type, becomes sexually mature and resides in a cyst formed from the tissues of the mesentery; (2) these cysts are so numerous in every individual fish examined that the mesentery becomes transformed into "a massive liver-like organ in which the various coils of the intestine appeared merely as tubes embedded therein"; (3) though two lateral main excretory canals are described, yet there is no terminal excretory aperture: the excretory system "is closed in all stages of [the parasite's] life-history"; (4) the whole of the parenchyma is "filled up with enormous numbers of minute egg-cells. Besides the eggs, morulae and other higher stages in the development of the young were also present in the intima." In other words, the egg-cells "develop in the body of the parent to form young worms identical in structure and appearance with the parent"; (5) the young worms "escape

[1] "Notes from the Bengal Fisheries Laboratory, No. 4, Cestode Parasites of Hilsa, *Hilsa ilisha* (Ham. Buch.)," *Records of the Indian Museum*, xv. 1918, p. 83. See also the *Journal of Parasitology*, iv. March, 1918, p. 128.

through a temporary aperture which is formed in the middle of the rostellum, anteriorly," and, when the old cyst has been ruptured, they become "scattered in the mesentery, the [new] cyst not having been secreted at this stage." This brief *résumé* of the views of Southwell and Prashad indicates that this parasite may indeed be unique and having collected, before I left India in April, 1922, a lot of carefully fixed and preserved material from the rivers at Allahabad (United Provinces), I thought it might be worth while to re-examine this supposed remarkable organism, if only in order to be able to supplement the somewhat meagre account of it provided by our authors. Unfortunately, as the sequel will show, practically every one of the above statements is erroneous, and *Ilisha parthenogenetica* proves to be only a Plerocercoid larva of the *Scolex polymorphus* type described by van Beneden (1850), Monticelli (1888), Zschokke (1889), Curtis (1911) and other authors. However, this larva does possess several very distinctive features not mentioned by previous authors.

While at Allahabad I collected samples of what our authors suppose to be cyst-infested mesentery from more than a dozen *Hilsa*. Since my returning to England I have cut serial sections of nine large pieces of this material from different fishes and have also isolated the minute larvae and full-grown *Ilisha p.* from teased-up preparations of these and other pieces. I may further mention that while at Allahabad I examined the living *Ilisha p.* and observed the "triangular patches of orange-red pigment situated near the anterior end, just posterior to the suckers, one on either side" referred to by Southwell and Prashad, but I did not then go into further details.

The naked-eye appearance of the supposed cyst-filled mesentery of the *Hilsa* is shown in Fig. 1, but a very brief examination soon proves that the supposed cysts occupied by the parasites are in reality only the numerous closely-packed pyloric caeca which, in this fish, arise from the wall of the first part of the anterior intestine, from the region of the pylorus to a varying distance posteriorly. In other words, the supposed cysts of *Ilisha p.* are merely normal parts of the normal Clupeoid gut and are lined by a typical mucosa, and it is therefore not surprising that "not a single *Hilsa* was found [by our authors] which was not similarly infected" with "cysts"! The pyloric caeca are, on the average, about 3 mm. in length, but may be longer (5 mm. being about the maximum length) or shorter. Each caecum is rounded at one end and at the other opens, without constriction, into the narrow intestine. Southwell and Prashad's statement that the "cysts" are closed at both ends is quite incorrect. It is true that, in addition to the pyloric caeca, there exist true cysts, each closed at both ends, orange-yellow in colour and secreted by the parasite itself, lying in the vascular and connective tissue external to and surrounding the mass of caeca, but these cysts contain Tetrarhynchid larvae in various stages of development and have no connection with *Ilisha p.* Examinations of the pyloric caeca of different specimens of *Hilsa* show that *Ilisha p.* was absent only in one fish out of nine examined, and that a species of *Echinorhynchus* was also present in four of these fishes. This species of *Echinorhynchus* comprises

individuals of various sizes, some smaller than the full-grown *Ilisha p.*, and it is possible that the eggs and larvae described by Southwell and Prashad from the body-substance of *Ilisha p.* were in reality the eggs and egg-clusters contained within the female *Echinorhynchus*.

II. Structure and Development of the Parasite.

The full-grown parasite, when present, is usually to be found at the extremity of a pyloric caecum (Fig. 3) and in no case have I observed more than one in each caecum, though there are often also present in the caecum a number of the small larvae. I have, however, occasionally found both the full-grown parasite and the small larvae in the wide lumen of the intestine (Fig. 2). The caecum thus serves as a brood-chamber in which one of a number of small larvae attains its full size, and under these circumstances special cysts for the enclosure of the parasites are unnecessary. I may also mention that the anterior end of the large parasite is always directed towards the closed end of the caecum, and that *Echinorhynchus* is not uncommonly also found in this position. The wall of the individual pyloric caecum, the structure of which is not indicated in Figs. 2 and 3, consists (1) of a thin outer longitudinal muscle layer, (2) a thick inner circular muscle layer, (3) a submucous coat, nearly as thick as the circular muscle layer, (4) a thin muscularis mucosae and (5) a thick folded mucous membrane. The small larvae lie in the folds of the mucous membrane, but this latter is largely destroyed when one of the larvae attains full size, and to some extent is also destroyed by the small larvae. The lumen of the caecum is thus full of detritus (Fig. 3) which doubtless serves as food for the larvae. The spaces outside of and between the caeca are occupied by loose areolar tissue and blood vessels, the latter often surrounded by extensions of the diffuse pancreas. Thus the pyloric caeca are transformed into a more or less solid mass, on the exterior of which the serous coat originally lay.

The full-grown *Ilisha parthenogenetica* is stated by Southwell and Prashad to attain a length of 2·4 mm. but the largest specimen I have found (Fig. 4) only measured 1·7 mm.—a difference probably accounted for by the former being measured when alive and my specimens being preserved. In all the parasites the body is flattened in transverse section but more so in the younger than in the older. The body as a whole is translucent when alive and the only coloured parts are the two patches of orange-yellow pigment situated just posterior to the suckers, one on either side. In preserved specimens this coloration disappears and its position is only indicated by a cluster of cells, closely adjacent to the anterior end of the excretory canals. The anterior end of the parasite (Fig. 4) is distinguished by being broader than the slightly tapering posterior end, by the possession of four circular suckers (*S*) with distinct slightly-raised margins, and by the presence of a remarkable terminal sac (*TS*) in the position usually occupied by the rostellum.

Along each edge of the flattened body, arising just anteriorly to the suckers and extending to the hind extremity of the body, is a pair of distinct much

convoluted (but possibly only sinuous in the uncontracted animal) *excretory canals*, one of the pair being much narrower in calibre than the other (Figs. 4, 12, 13). These two canals apparently unite anteriorly, both receive the fine relatively short ducts terminating in flame-cells (Fig. 12), and both open quite distinctly and independently into the median terminal invagination of the subcuticula which forms the terminal excretory duct (Fig. 13).

There can also be seen, faintly in whole-mounted specimens, but clearly in sections, ten narrow longitudinal *muscle strands* which stretch the entire length of the animal (Figs. 4, 6, 8, 9). A pair of these lie along each edge of the body, adjacent to the excretory canals, thus forming the four *marginal longitudinal muscles* (*MLM* in Fig. 6), and the remaining six—the *lateral longitudinal muscles* (*LLM* in Figs. 6, 8, 9)—lie between the two pairs of marginals, on each side ("upper" and "lower") of the body. The marginal muscles are situated in line with the four suckers and they apparently end anteriorly by twisting round the neck or upper part of the pharynx-like terminal sac, the fibres running obliquely, and they also give off in each case a small branch to the subcuticula external to the sucker, each muscle therefore dividing into a large and a small branch. The six lateral longitudinal muscles, on the other hand, end anteriorly in the subcuticula surrounding the anterior opening of the terminal sac. All of these ten muscle strands branch at the extreme posterior end of the body and apparently become attached to the terminal subcuticula. It would thus appear that the function of the lateral longitudinal muscles is to contract the body longitudinally, and of the marginal longitudinal muscles to retract the terminal sac to a small extent in addition, but none of these muscles can be concerned with the extreme retraction of the sac, suckers and terminal subcuticula shown in Fig. 9, since, as the figure shows, the muscle bands, in this condition, take a recurved course. This extreme retraction is possibly effected by the extremely sparse longitudinally disposed fibres which ensheathe and extend a short distance behind the terminal sac and which I have labelled *RTM* in Figs. 8 and 9, but I am doubtful if these fibres are really muscular and I only make the suggestion because otherwise an appropriate muscular mechanism appears to be absent. Protrusion of the terminal sac and suckers is probably effected by the circularly disposed band of longitudinal muscles developed from the thickened subcuticula just below the suckers (*PRM* in Figs. 8 and 9). None of the longitudinal muscle bands mentioned appeared to have a direct connection with the suckers.

A pair of longitudinal *nerves* is also present, each of the pair lying just external to the excretory vessels (*N* in Fig. 6). The two nerves form a loose ring round the anterior end of the terminal sac.

The *terminal sac* is relatively large, about one-eighth the length of the entire body even in the full-grown, though contracted, parasite and proportionately larger in smaller individuals. Its wall is composed of columniform, apparently muscular, cells, separated, in preserved material, by distinct spaces which often contain rows of smaller interstitial cells. The ends of these columni-

form cells next the cavity of the sac appear to be vacuolated, and the opposite external ends are clear of granular substance for a short space under the outer limiting membrane. The sac is not lined by a cuticle. The wall of this sac bears a distinct resemblance in general structure to the muscular pharynx of Trematodes, but, on the other hand, is quite distinct histologically from the muscular suckers (cf. Figs. 10 and 11), hence I have named this sac the "terminal sac" and not "terminal sucker." A thin layer of circular muscles surrounds the wall of the sac, lying internal to the sparse layer of longitudinal fibres already mentioned. The subcuticula extending from the opening of the sac to the suckers is thin though cuticled and easily folded when the sac is retracted. In the fully-everted condition of the terminal sac, the opening is situated well anterior to the suckers, especially in the young larva (Fig. 17), and I am inclined to think that it was this forward protrusion of the terminal sac which led Southwell and Prashad to imagine that they saw a "larva" being extruded from the body of their adult *Ilisha parthenogenetica* (cf. their Fig. 7 with my Fig. 17). The terminal sac of *Ilisha parthenogenetica* is probably the most gut-like vestige yet described in the Cestoda and is certainly larger than the similar structures described by Monticelli (1888) and others in the *Scolex* larva, and apparently differs also in that it is not lined by a cuticle.

The general parenchyma which forms the substance of the body is continuous, no trace of cavity being present, and contains, apart from the larger structures already mentioned, numerous calcareous bodies, fine nerve and muscle fibres, the flame-cells and fine excretory ducts in the region of the excretory channels. There is thus nothing remarkable in this parenchyma and this fact, which I have verified by the careful examination of at least eighty whole-mounted full-grown specimens and of some thirty to forty full-grown specimens in longitudinal and transverse section, is of importance in view of the statements made by Southwell and Baini Prashad to which I have already referred. These authors, in addition to stating that the parenchyma is filled with eggs, morulae and other young stages of developing larvae, assert that on two occasions they have actually seen larvae escape from a rostellar opening in the living animal. These statements are most certainly incorrect. They possibly owe their origin to the initial mistake of supposing that the full-grown parasite exists in a *closed* cyst, to deceptive appearances observed in larvae seen through the wall of the pyloric caecum, and possibly also to female *Echinorhynchus* being included among the *Ilisha*.

The youngest larva I have found measured 73 × 55 microns and is illustrated in Fig. 14. Even at this early stage the suckers can be everted. Figs. 15, 16 and 17 represent older stages of growth. In these young stages and in all stages intermediate between these and the full-grown form there is no trace of the "receptaculum capitis" of Leuckart, since the slight connective tissue or muscular investment of the terminal sac can hardly be so regarded. It is also to be remarked that the terminal sac is much more rostellum-like in these young larvae than in the full-grown form.

Finally I may mention that in the anterior intestine of one *Hilsa* I found large numbers of the typical unarmed Cestode eggs shown in Fig. 18. These eggs measured 36·6 × 32·9 microns in the majority of cases, but a few were longer (38·4 microns). I do not pretend that there is any connection between these eggs and the *Ilisha* larvae, though there may be. I must also mention that in the caeca of another *Hilsa* I found a number of large spheres, 0·5 mm. in diameter, full of dense yolk-like matter containing nuclei, vacuolated at the periphery and enclosed by a thin cuticle or shell slightly wrinkled. I am ignorant of the nature of these bodies.

III. *Ilisha parthenogenetica* as a Plerocercoid Larva of the *Scolex* Type.

From the above description of *Ilisha parthenogenetica* it is evident that this form is solely a solid parenchymatous Cestode larva, doubtless developed in the fore-gut of the *Hilsa* from swallowed eggs. The latter develop into the small larvae usually before reaching the pyloric caeca, and when they have reached this haven, some of these larvae assume the full-grown form. The ultimate fate both of the full-grown and the small larvae is at present unknown, but since the *Hilsa* is preyed upon by many predaceous fishes, the adult sexual form of *Ilisha parthenogenetica* will, unless it resembles *Proteocephalus ambloplitis* (Cooper, 1915) which inhabits the same host as its larva, doubtless be discovered in one of these[1]. The name *Ilisha parthenogenetica* must therefore be deleted as having reference to a sexual form which has no existence.

Solid parenchymatous Cestode larvae in general have been described under a number of pseudo-generic names—*Scolex* (Mueller, 1787), *Dithyridium* (Rudolphi, 1819), *Piestocystis* (Diesing, 1850), *Sparganum* (Diesing, 1850), *Plerocercus* and *Plerocercoides* (Braun, 1883), but the term "Plerocercoid" can be applied to all these forms collectively. Reviewing briefly what is as yet known of the structure of these various larvae, it would appear that there exist two main types of plerocercoid: (1) the *Sparganum*, Dibothriocephalid or Dibothridiate type, in which the body is elongated and more or less flattened, the anterior end with or without two incipient or well-developed grooves or distinct "bothria," but never with four sucker organs, with a pointed invaginable extremity, with a more or less irregular system of excretory canals (not comprising longitudinal channels lying only in one longitudinal plane of the body), and with two nerve cords which unite anteriorly; and (2) the Tetrabothridiate type of larva usually known under the names of *Scolex*, *Dithyridium* or *Piestocystis*. This type of larva also possesses an elongated more or less flattened body but the anterior end always carries four sucker organs, has usually a pair of excretory canals on each side of the body[2] and

[1] I found a recently swallowed *Hilsa* in the stomach of a *Bagarius yarrelli* (the "Goonch") from the Ganges, but no change was to be detected in the condition of the *Ilisha* larvae and Cestodes were absent from the intestine of the "Goonch."

[2] Possibly the numerous descriptions of only one canal on each side of the body are in some cases correct.

with two lateral nerves connected anteriorly by a ring and usually situated external to the excretory canals.

In view of our present incomplete knowledge of the structure of this second type of larva, it is not always possible to distinguish between the *Scolex* and the *Dithyridium* (*Piestocystis*) variety. The *Scolex* larva usually possesses bothridia, or more or less elongated muscular cups with raised margins and often subdivided into loculi, as distinct from the more simple acetabula of the *Dithyridium*, but this does not appear to be always the case[1]. Both types of larvae possess a pair of excretory canals and a nerve on each side of the body, and Diesing's statement (1850) that the *Piestocystis* is devoid of a rostellum, though he admits an "os terminale," while *Scolex* possesses a haustellum (1854) is certainly indefensible.

Whether or not the *Scolex* larva[2] is in all cases distinguishable from the *Dithyridium*[3], it is certain that *Ilisha parthenogenetica* very closely resembles the *Scolex* larvae described by van Beneden, Monticelli, Curtis and others, and despite the presence of acetabula-like suckers in the specimens I have examined (also see Southwell and Prashad), must be included with them. Like many of these *Scolex* larvae, *Ilisha p.* is found in the intestine of a Teleost fish[4] and it further resembles many *Scolex* larvae in that it has two anterior patches of orange pigment, a saccular unarmed haustellum and two pairs of excretory canals.

Postscript (December 5th, 1922). After completing the preceding description of *Ilisha parthenogenetica* I received information that Messrs Southwell and Baini Prashad, despite their previous publication of two papers embodying the statements I have quoted, now hold the opinion that this parasite is only a plerocercoid larva, and that they intend to publish a Note on the subject in the *Records of the Indian Museum for* 1923. Since my description of this larva, however, probably includes an account of many matters which a Note of correction will not contain, I refrain from withholding it.

REFERENCES.

Alessandrini, G. (1907). Sur un *Dithyridium*, Rud. del Polmone di Gallina. *Boll. Soc. Zool. Ital.*, Ser. 2, VIII. 49.

Beneden van P.-J. (1850). Recherches sur la Faune Littorale de Belgique. Les Vers Cestoïdes. *Mém. Acad. Roy. de Belgique*, XXV.

[1] *E.g.* the *Scolex* larvae of *Ichthyotaenia filicollis*, Rud. (Meggitt, 1914), of *Ichthyotaenia torulosa*, Batsch (Wagner, 1916), and *Proteocephalus ambloplitis*, Leidy (Cooper, 1915), and the *Plerocercus africanus* of Daday (1910–1911) and *Plerocercoides aequoreus* of Wundsch (1912), appear to possess ordinary taenioid suckers. Even the young *Scolex polymorphus* bears sucking organs which at first appear to be indistinguishable from typical acetabula (Curtis, 1911).

[2] Found in Fishes and representing the larva of Tetraphyllidea and Tetracotylean Ichthyotaeniidae.

[3] Found in Vertebrates above Fishes and probably representing the larvae of certain Anoplocephalinae and Mesocestoididae.

[4] The larva of *Proteocephalus ambloplitis* is, like *Ilisha p.*, associated with a species of *Echinorhynchus* in the pyloric caeca.

COOPER, A. R. (1915). Contributions to the Life History of *Proteocephalus ambloplitis*, Leidy, a Parasite of the Black Bass. *Contrib. Canadian Biology, Suppl. 47th Ann. Rep. Depart. Mar. Fish.*, Fasc. II. 177.

CURTIS, W. C. (1911). The Life History of the *Scolex Polymorphus* of the Woods Hole Region. *Jour. Morph. Phil.* XXII. 819.

DADAY, E. v. (1910–11). Untersuchungen über die Süsswasser-Mikrofauna Deutsch-Ostafrikas. *Zoologica*, XXIII. 42.

DIESING, C. M. (1850). *Systema Helminthum*, I.

DIESING, K. M. (1854). Über eine naturgemässe Vertheilung der Cephalocotyleen. *Sitz.-Ber. Math.-Naturw. Cl. Kais. Akad. Wiss. Wien*, XIII. 556.

FRAIPONT, J. (1881). Recherches sur l'Appareil Excréteur des Trématodes et des Cestodes. *Archiv. de Biol.* II. 1.

HILL, J. P. (1894). A Contribution to a further Knowledge of the Cystic Cestodes. *Proc. Linn. Soc. N. S. Wales*, 2nd Ser. IX. 49.

LINSTOW, v. (1892). Beobachtungen an Helminthenlarven. *Archiv f. Mikr. Anat.* XXXIX. 325.

MEGGITT, F. J. (1914). The Structure and Life-History of a Tapeworm (*Ichthyotaenia filicollis*, Rud.) parasitic in the Stickleback. *Proc. Zool. Soc. London*, I. 113.

MONTICELLI, FR. SAV. (1888). Contribuzioni allo Studio della Fauna Elmintologica del Golfo di Napoli. I. Ricerche sullo *Scolex polymorphus*, Rud. *Mitth. Zool. Stat. zu Neapel*, VIII. 85.

MRÁZEK, AL. (1915–16). Cestoden-Studien. II. Die Morphologische Bedeutung der Cestoden-Larven. *Zool. Jahrbüch. Jena, Anat.* XXXIX. 515.

MUELLER, O. F. (1787). Verzeich. bish. entdeck. Engeweidewürmer, Thiere etc. *Naturforsch., Halle*, XXII. 33.

ROSSETER, T. B. (1891). On a new Cysticercus and a new Tapeworm. *Jour. Quekett Micros. Club*, 2nd Ser. IV. 361.

STOSSICH, M. (1898). Note Parassitologiche. *Boll. Soc. Adriatica Sci. Nat. Trieste*, XVIII. 1.

VALENCIENNES, M. (1844). Observation d'une Espèce de Ver de la Cavité Abdominale d'un Lézard vert-piqueté des Environs de Paris, le *Dithyridium lacertae*, Nob. *Ann. d. Sciences Nat.*, 3rd Ser., Zool., II. 248.

VAULLEGEARD, A. (1895). Sur les Helminthes des Crustacés, Décapodes, Brachyoures et Anomoures. *C. R. Trav. Assoc. Franç. Avance. Sciences*, 24 Session, Bordeaux, Part II. 662.

WAGNER, O. (1916). Über den Entwicklungsgang einer Fischtänie. *Zool. Anzeig.* XLVI. 70.

WELLMAN, C. and WHERRY, W. B. (1910). Some new Internal Parasites of the Californian Ground Squirrel (*Otospermophilus beecheyi*). *Parasitology*, III. 417.

WUNDSCH, H. H. (1912). Neue Plerocercoïde aus Marinen Copepoden. *Archiv Naturgesch.* LXXVIII. Abth. A, Heft 9, p. 1.

ZSCHOKKE, F. (1889). Recherches sur la Structure Anatomique et Histologique des Cestodes. *Mém. de l'Inst. Nat. Genevois*, XVII.

DESCRIPTION OF PLATE V.

LETTERING.

♂♀ *ECH*, ♂ and ♀ *Echinorhynchus*; *EXC*, excretory canal; *EXCB*, excretory canal of wide calibre; *EXCL*, excretory canal of narrow calibre; *FLC*, flame-cell; *IL*, *Ilisha parthenogenetica*; *INT*, internal surface of terminal sac and sucker; *L*, lumen of intestine; *LAR*, small larva; *LLM*, lateral longitudinal muscle; *MLM*, marginal longitudinal muscle; *N*, nerve; *PC*, pyloric caecum; *PRM*, protractor muscle; *RTM*, retractor muscle (?) of terminal sac and anterior end of body; *S*, sucker; *TS*, terminal sac; *TXP*, terminal excretory pore.

Fig. 1 (× 1). Surface view of the pyloric caeca attached to the wall of the anterior intestine (the lumen of the intestine, *L*, is shown at the anterior end only, the intestine having been torn off posteriorly).

Fig. 2 (× 5). Transverse section of the intestine and its caeca to indicate the positions in which the small and large *Ilisha parthenogenetica* larvae and *Echinorhynchus* were found (the mucosa and other layers of the intestine and caeca and inter-caecal tissue are omitted).

Fig. 3 (× 21·5). A single pyloric caecum (mucosa and other layers of wall not indicated) containing a large *Ilisha p.* and many small larvae, viewed in optical section.

Fig. 4 (× 39). An *Ilisha p.* measuring 1·7 mm. in length and 0·249 mm. in breadth, *in toto.*

Fig. 5 (× 180). Horizontal section through anterior end of *Ilisha p.* showing the terminal sac and suckers only slightly retracted, and two of the lateral longitudinal muscles.

Fig. 6 (× 56). Transverse section across the body of *Ilisha p.* anteriorly, showing the ten longitudinal muscles, the small and large excretory canals on each side and the two nerves.

Fig. 7 (× 530). Transverse section through the cuticle and subcuticula, showing the thin outer circular muscle layer, the thicker internal longitudinal muscle layer and the subcuticula.

Figs. 8 and 9. Diagrams constructed from serial sections through the everted and retracted anterior ends of *Ilisha p.*

Fig. 10 (× 530). Horizontal section through the wall of the terminal sac.

Fig. 11 (× 530). Horizontal section through the wall of a sucker.

Fig. 12 (× 530). The large and small excretory canals and two flame-cells seen in a transverse section.

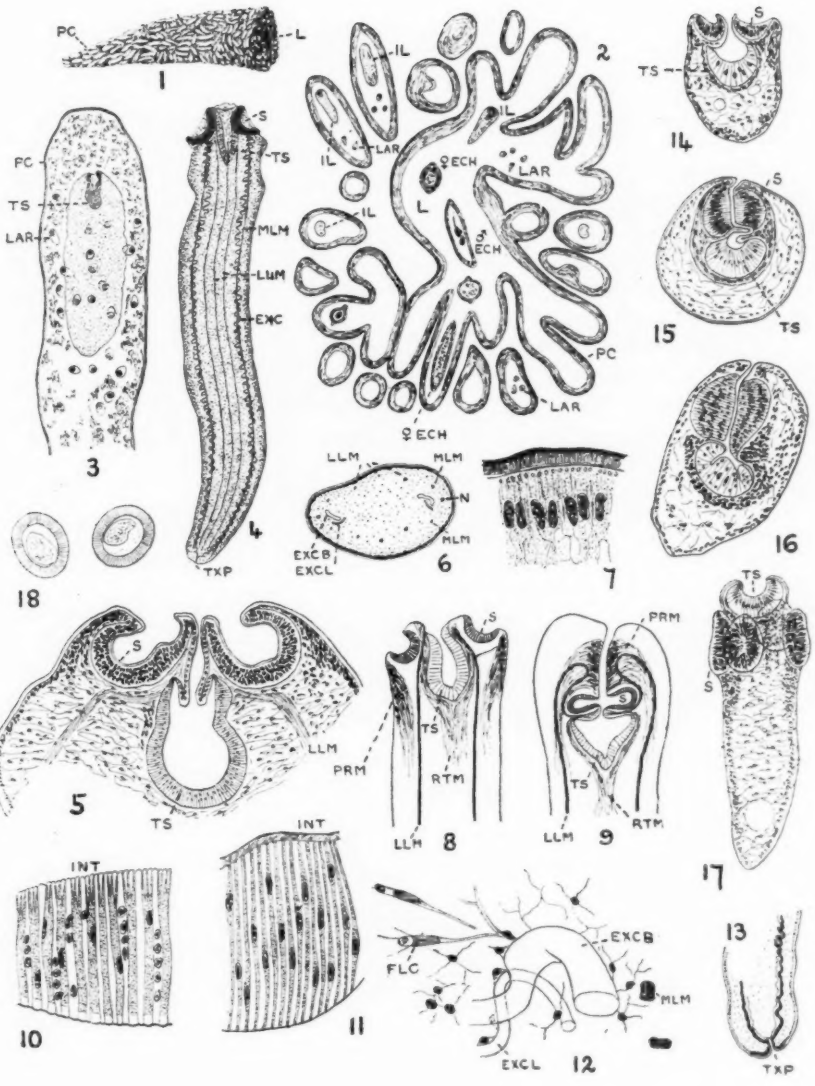
Fig. 13 (× 56). The opening of the two excretory canals on each side of the body to the exterior at the posterior end of the body (drawing constructed from three serial sections).

Fig. 14 (× 260). The youngest larva found.

Figs. 15 and 16 (× 260). Two other young larvae.

Fig. 17 (× 180). An older larva with terminal sac protruded.

Fig. 18 (× 260). Cestode eggs found in the anterior intestine of one *Hilsa.*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NOTE ON *PROCAMALLANUS SPIRALIS* BAYLIS, 1923 [NEMATODA].

By H. A. BAYLIS, M.A., D.Sc.

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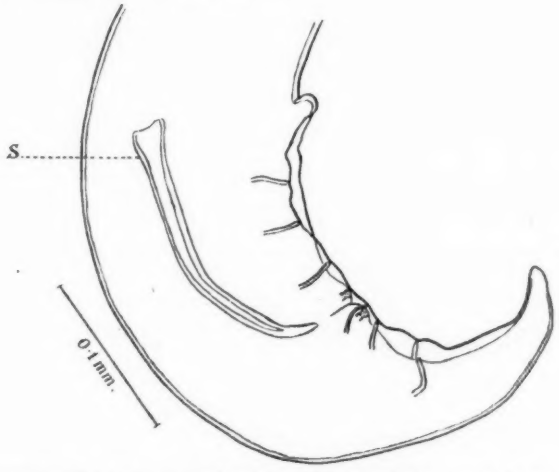
In a recent contribution to *Parasitology* (present volume, p. 26) a short description of the male of this species was given. The type-material consisted of a single male from the Silurid fish, *Heterobranchus anguillaris*, from Cairo. Through the kindness of Dr W. N. F. Woodland, of the Wellcome Bureau of Scientific Research, the writer has recently had the opportunity of examining further material belonging evidently to the same species, the host being *Synodontis eupterus* and the locality Khartoum. This material consists of several males, one mature and two immature females, all mounted as microscopic preparations in glycerine-jelly. A few further details may now be added to the description of the species.



Procamallanus spiralis. Caudal end of male; lateral view. *s.*, right spicule.

The dimensions of the mature female are as follows:

	mm.
Length	22·25
Maximum thickness (specimen possibly slightly flattened)	0·4
Length of buccal cavity	0·09
Distance from ant. end to end of muscular portion of oesophagus	0·58
" " " end of glandular portion of same	1·1
" " " nerve-ring	0·27
" " " vulva	9·25
Length of tail	0·16

The arrangement of the female genital organs appears to be the same as in *Camallanus* and other members of the family Camallanidae, there being only one ovary, and the posterior branch of the uterus ending blindly. The vagina runs straight backwards from the vulva. The uterus contains numerous free embryos of considerable size.

The caudal papillae of the male have not been described. As far as can be made out from the present material (see text-fig.), there are seven pairs of rib-like papillae in the thickness of the caudal alae, and two pairs of papillae with shorter peduncles, situated ventrally, one pair on the anterior and one on the posterior lip of the cloacal aperture. It is uncertain whether there are any small papillae nearer to the extremity of the tail.

SOME POINTS RELATING TO THE MORPHOLOGY AND DEVELOPMENT OF *SARCOCYSTIS TENELLA*.

By J. P. McGOWAN, M.A., M.D., B.Sc.

The Rowett Research Institute, Aberdeen.

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I. Introduction.

The investigations, to be recorded here, were carried out during an inquiry into the important disease of sheep in Scotland, "Scrapie." This is believed to be caused by the *Sarcocystis tenella*. It would be desirable, therefore, to give a brief outline of the characteristics of this disease as an introduction.

II. Description of "Scrapie."

Historical. "Scrapie," under various names, has been known in Britain since at least 1732. At the present moment, its ravages are principally felt in the Border Districts of Scotland and England. It has been noted in Germany, under the names "Gnubber-Krankheit" and "Traber-Krankheit," since the middle of the 18th century and in France, for a like period, under the designation "La Tremblante."

Mode of Occurrence. Its occurrence has always been in association with attempts to improve the breeds of sheep, which in their turn are always associated with a considerable amount of in-breeding. Highly pedigreed flocks are especially prone to it.

No breed seems to be exempt from the disease. It affects both sexes, as well as castrated animals, probably in equal degree. The great majority of the animals are first affected when they are from one and a half to two years old. The disease at this age runs a much more acute and fatal course. Very few cases occur before the animal reaches one and a half years. A considerable number of cases, however, appear when the animals are from two and a half up to eight years of age. These cases are, however, more chronic in character and their frequency diminishes as the animal grows older. It has also been noticed that, as the disease disappears by remedial measures from a flock, the last few cases are in the older ages. There are observations which tend to show some relation as existing between the onset of the disease and the existence of pregnancy. Thus, the maximum number of cases of the disease occurs when the ewes are having their first lamb. There is probably no relation between the season of the year and the appearance of the disease. The duration of illness varies in individual sheep. Sometimes they die after a very short illness and while they are as yet in good condition, at other times the illness is protracted and the animal dies in an extremely emaciated and weak condition. Very few recoveries are recorded, although these undoubtedly do occur in the sense that the animal loses the symptoms.

Symptoms. According to the predominance of the symptoms, the disease has been divided into two varieties, the Itchy variety and the Paretic variety. Names, corresponding to these, have been given. Thus in Britain the disease is known as "Scrapie" or "Cuddie-trot," while in Germany, it is designated as "Gnubber-Krankheit" and "Traber-Krankheit." There are often mixtures of these two varieties, but, while the itching may occur in the affected sheep when it is fat or when it is lean and emaciated, the trotting occurs only in the latter condition.

There is no condition of the skin to account for the itchiness although, in the later stages owing to the rubbing, the wool may be torn off and there may be excoriations. The trotting gait appears later in the disease, when the animal becomes much emaciated. Physical examination of the nervous system, as well as histological examination of its various parts, shows that the disease is not one of the nervous system. On *post mortem* examination, in uncomplicated cases of the disease and apart from the lesions produced by the rubbing, nothing is found except an extremely watery gelatinous appearance of the skeletal muscles, which, on microscopic examination, are seen to be heavily laden with sarcocysts. As many as 90 sarcocysts were found in 15 milligrammes of muscle of some of these cases.

Mode of Spread. It is not contagious in the ordinary sense. The most common method of its transmission is from the mother to her lamb. Cases do occur, however, but rarely, where a diseased mother has produced a lamb which never took the disease. On the other hand, an apparently healthy mother may give birth to a lamb which eventually dies of scrapie. The disease is not transmissible from sick to healthy by the inoculation of the organs

of the sick into the healthy (McFadyean). There is no evidence that the disease is spread by the ram.

Distribution in Scotland. At the present time the disease has a peculiar distribution in Scotland. It is more or less limited in endemic proportions to a certain area, where improvement of sheep breeds with consequent inbreeding and a special type of breeding, to be discussed shortly, hold sway. In explanation of this, it may be pointed out that inbreeding, apart from the disputed question as to whether it weakens the constitution, tends to perpetuate and spread any hereditary disease, such as this is, once it gets entrance to the flock. Again the practice in this area is to keep up the ewe stock of the flock, from the two-year old ewes—that is from the age at which the maximum occurrence of this—a hereditary disease—occurs. It will be seen how, under such circumstances, by a process of geometric progression, from a single case of the disease, the flock in a few years can be thoroughly saturated with it. It should be mentioned, however, that the inbreeding and breeding from the two-year old ewes is not postulated as the cause of the "first" cases but as a means of spreading the disease, once these "first" cases have arisen. How they may arise will be discussed later. On the other hand, in other parts of Scotland, where sheep breeding on more purely commercial lines takes place (where also, however, the sheep harbour sarcocysts and where indeed these "first" cases above referred to also occur), scrapie is hardly known or recognised. Such "first" cases, in these parts, are in most instances thought to be sheep-scab and treated as such. Here the practice is to keep up the ewe stock from the best lambs from all ages of ewes up to five or six years old. In this way the lamb of a two-year old ewe, being a poor lamb, is rarely chosen. However, should it or any other ewe develop scrapie, the lamb of such a ewe being poorly nursed would be a poor lamb and would stand no chance of being chosen for stock. The disease is thus kept from spreading in the flock. Although there is free intercourse and movement of sheep from the endemic area to other parts of Scotland, the disease has not established itself in these parts, bearing out the non-contagious view of its nature.

Mode of Control. It was suggested, as a method of dealing with the disease, that the practice of keeping up the ewe stock from the two-year old ewes should be abandoned, and, that the ewe stock should be kept up from the progeny of the oldest ages of ewes in the flock. This suggestion has been adopted by some flock masters with perfect success, even in already diseased flocks, the disease being entirely eradicated in this way in a few years.

III. Cause of the Disease and Origin of "First" Cases.

It should be kept in mind that the sarcocyst, which is here alleged to be the cause of the disease, is omnipresent in sheep, that cases are of frequent occurrence where the disease had appeared in the lamb of an apparently healthy mother (in diseased and healthy flocks alike), and that unimported cases of the disease exist sporadically throughout the flocks in Scotland away

from the endemic area. Again the idea underlying the explanation of the disease by the sarcocyst is that when the sarcocysts develop to a certain extent in the body of the animal, then the symptoms of the disease begin to appear. The origination therefore of the "first" cases would appear to be virtually the same as this, namely, why in one instance a sheep should be found at eight years old or older with sarcocysts practically absent (but still discoverable) and in another case a sheep at two years old should be over-run with them. The virulence of the strain of sarcocyst may have to do with this. On the other hand evidence is not wanting that the resistance of the sheep, shown at times by the breed and the nature of its feeding (which influences its growth) may play an important part in the onset of symptoms.

IV. Possible Methods of Transmission of the Sarcocyst from Individual to Individual.

Previous to the work detailed here it was known that in omnivorous animals such as the mouse (Smith, 1901 and 1905) the sarcocyst was passed from one animal to another by their eating one another. Obviously this could not be the method of passage in the sheep. To test the common belief in the hereditary transmission of the disease, an experiment was undertaken to see if the sarcocyst was passed from the mother to the lamb *in utero*. Four lambs were removed from their scrapie mothers immediately on birth before they had even sucked, were taken to an enclosure where sheep had never been before and were brought up on the bottle with cow's milk. The lambs were separated into two lots and on one lot were put keds (*Melophagus ovinus*) removed from scrapie sheep. At six months of age, the lambs which did not have the keds put on them were still free from them and sarcocysts were found in pieces of the gluteal muscles of all four lambs. The sarcocysts can therefore be passed without the aid of keds and the same can be said, regarding the other common ectoparasite of sheep in Scotland, namely the tick (*Ixodes ricinus*). The conclusion seems to be from this experiment that the sarcocyst may be passed from the mother to the lamb in the uterus. The only possible objection to the validity of this conclusion is that the cow's milk, with which the lambs were fed, was unboiled as it was found impracticable to rear the lambs on boiled milk. Against this, however, it has to be said that the sarcocyst, found in the lambs, appeared to be *Sarcocystis tenella* and that one, of a possible three (the other died prematurely of an acute disease) of the sheep, developed typical "scrapie" and died of it at two years old. It would appear thus that "scrapie" can also be transmitted to the lamb *in utero* from the mother, a fact which has been known empirically since the disease was first observed.

V. Experimental Transmission of Scrapie.

Another experiment was then undertaken to see if "scrapie" could be transmitted in any other way. The lambs from six "scrapie" mothers were removed from these mothers and in their place six lambs born from healthy

mothers were substituted. These lambs sucked the mothers till the mothers died or became too weak to nourish them. On the average this happened in about a month. Thereafter they were brought up on cow's milk. In due course the whole of these six lambs died from "scrapie." No case of the disease however occurred in lambs born from and brought up on healthy mothers which were closely intermingled with these experimental lambs during the whole course of the experiment. The contact apparently could be very intimate, provided actual sucking was excluded. It would appear therefore that "scrapie" can be transmitted through the milk of the affected mother. By implication it would also appear that the sarcocyst in some form or other passes out in the milk of the mother, and presumably in high concentration as the positive cases by this method were more numerous than in the intrauterine method. It would further appear from this experiment as if virulence of the sarcocyst might be a determining factor in the origin of the disease, as the substituted lambs in all probability had harboured a few sarcocysts, of low virulence however, to begin with.

VI. Explanation of the Symptoms, etc.

The two prominent symptoms of the disease, as has already been mentioned, are the itching and the paresis. With regard to the itching, it was found experimentally that the injection intravenously into the rabbit of an extract of the sarcosporidial cysts produced within a short time extreme itching of the animal, as evidenced by its scratching itself, great uneasiness, shaking its head, champing its jaws, biting its paws, etc. This stage lasted for a considerable time—two to three hours—and was followed by a stage of great prostration and eventual death of the animal. The action of the posion—sarcocystin—is thus similar to that of the extract of the tentacles of sea anemones (Richet, 1909), and of the fluids of the hydatid cysts of man, ox, sheep, etc. (Perret, 1909). In the diseased sheep the action of the poison is not so fulminant as this. It is of a milder nature but spread over a longer time. It may be supposed that in this condition there is a constant leakage from the cysts of small amounts of the toxin which keeps up a lasting state of itchiness and more or less weakness. Its action in these instances may be compared with the different results following on the injection of adrenalin and from the action of the suprarenal gland in health.

The paresis would appear to be explicable by the depressant action of the toxin together with the mechanical interference of the parasites with the contractions of the muscle.

Of the other phenomena of the disease, the long incubation period (two years) would be explained on the assumption of the time required for the growth of the parasite to such proportions as to give rise to symptoms, which, as has already been mentioned, appear when the infection reaches a certain stage. The production of symptoms may also depend somewhat on the virulence or nature of the infecting strain. It may be mentioned in passing

to complete this aspect of the subject that there would appear to be no phenomenon in connection with the disease to which the sarcosporidial view of its causation does not give a very ready and unforced explanation. This matter is too extensive, however, to be entered into in detail here. It is fully discussed elsewhere (McGowan, 1914).

VII. *Modus operandi* of the infection with and some points relating to the minute histology of the Sarcocyst.

In dealing with this, the subject of the zoological position of the sarcosporidia and the problem of the occurrence of sporogonous and schizogonous generations in their development (Crawley, 1916, 3 and 379) will be more or less untouched, as also the debated question of the exact nature of Alexeieff's nucleus (Alexeieff, 1911 and 1912), and Erdmann's "Fadenapparat" (Erdmann, 1914). Certain points may, however, be brought forward which do not appear to have been taken into account in the consideration of these problems heretofore.

It has already been suggested (*vide supra*) that infection in the sheep takes place by the intrauterine method and through the milk of the mother. It now remains to be discussed how exactly this may come about and also how the parasite spreads from one muscle fibre to another in an already infected animal. Many would appear to believe that the actual agent is the sickle itself. Marullaz (1920) is the latest who appears to hold this view. Some points may therefore be discussed which would appear to show the unlikelihood of this process being correct.

Histology of Sarcocyst. The sarcosporidial cyst when fully developed is surrounded by a cuticle, covered with "cilia" which penetrates into the substance of the muscle fibre. This cuticle, according to some, is traversed by fine pores and according to others (Bertram, 1892) shows fine clefts. These pores and clefts are very minute and neither are of such a size as to give one the idea that the body of the sarcosporidial sickle (provided it has the power of movement) could pass through them. There is no evidence, however, that the sarcosporidial sickle has motility and it would appear that the only way in which the sickle might get out would be by the bursting of the lining cuticle. If, however, this lining cuticle burst as a regular routine in the process of dissemination of the sarcocyst one would expect to find evidences of it. Thus, one ought to see irregularities in the shape of the *Sarcocystis tenella* cysts, while some of them would be of large size, extra fibrillar and surrounded by a fibrous capsule. This does not happen in the sheep except possibly in the oesophagus where rapid and extensive dilatations of the tube by the passing of a bolus would tend to burst the cyst and gives rise to the large forms known as *Balbiania*[1]. It seems unlikely therefore that the sickle could escape from the cyst to serve as a means of further infection.

[1] It may be mentioned that the *Balbiania* forms of the oesophagus are rare in "Scrapie" sheep.

Nature of the Sarcosporidial Spore. Various views are held regarding the significance of the sickles or spores. Laveran and Mesnil (1899) think that they are not spores in reality in that they do not represent a form under which the parasite could preserve itself in the outer world. Again others such as Negri (1908 and 1910), Fiebeger (1910) (quoted by Minchin (1912)), V. Betegh (1909), and Teichmann (1911), believe that these spores reproduce themselves by fission and so again are not spores in reality. Erdmann (1914) points out in this connection that it is not the spores but the sporoblasts which reproduce themselves thus. A further circumstance which would render very unlikely the division of the spores in such a manner was also pointed out by me in 1914 (McGowan, 1914). If the sickles or spores are emulsified in a 10 per cent. acetic acid solution deeply tinged with thionin blue it will be seen that they are surrounded by a definite hyaline capsule. This capsule can be seen even in unstained preparations, but in preparations made by the method just described, the unstained hyaline capsule is easily seen by contrast with the stained protoplasm of the parasite. Especially is this so at the sharp end of the sickle,

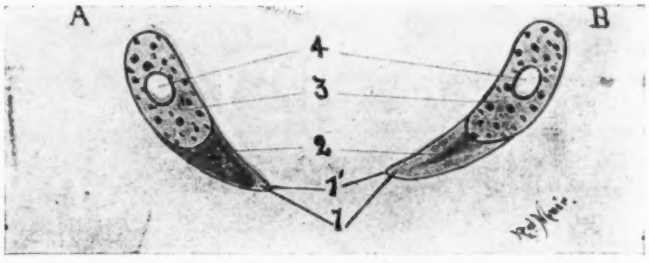

Fig. 1. The minute structure of the sickle (spore) of *Sarcocystis tenella.* (For explanation see the text.)

where a V-shaped space is left between the rounded end of the protoplasm and the capsule. This capsule too, is brought into evidence by the changes which the sickle undergoes in 1 per cent. glucose water to be referred to subsequently. Again, if the contents of a ripe cyst are examined fresh, there will be seen among the central débris of the cyst, these capsules rounded in form and emptied of contents. Erdmann (1914) in a paper, published practically synchronously with mine, figures this capsule in the spores (Pl. XVIII, figs. 27, 28, 30, 34, 35, 36) but would appear to attach no significance to it.

The minute structure of the sickle as depicted in Fig. 1, would appear to be as follows: the capsule is indicated by the numeral (1) and the number (1′) indicates the V-shaped space between the capsule and the protoplasm at the sharp end of the spore. The spore has a sharp and a blunt end. The "nucleus" (4) remains uncoloured practically when stained. The nucleus is surrounded by a zone (3) containing many chromatin granules, some of fairly large size. Situated near the sharp end of the spore and apparently definitely differentiated

from the zone (3) is a zone (2) which contains no granules. Spores such as described are seen when the contents of a ripe cyst are examined in saline under the high power of a microscope. One sees, however, in addition numerous small granules about 1 μ in size scattered all over the field, empty capsules now rounded in shape, and pieces of vacuolated material some containing small granules, others emptied of them.

The chromatic granules just referred to would appear to have been derived from the chromatic material of the nucleus which has wandered out. The region (2), containing no granules and delimited from (3), might be an instrument which by swelling out under certain conditions mechanically ruptures the capsule and sets free the mass (3) containing the granules. That it is separate and distinct from the rest of the protoplasm inside the capsule may

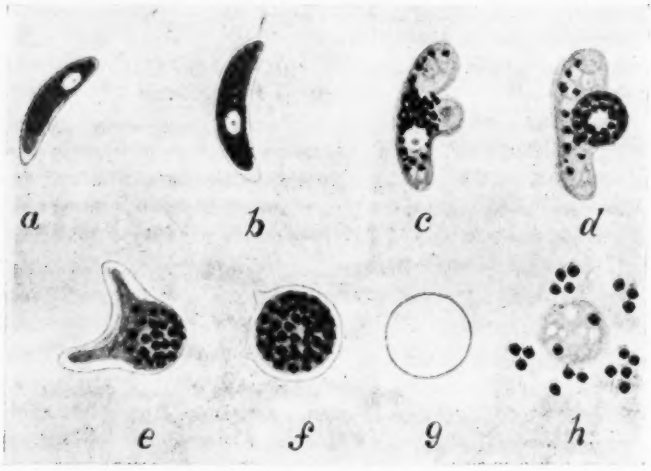

Fig. 2. Changes occurring in the sickle of *Sarcocystis tenella* kept in 1 per cent. solution of glucose.

also be inferred from what happens to it sometimes when the sickles are kept in ascitic fluid. The part (3) remains quite distinct and unaltered but this part shrivels up and gives the appearance shown in Fig. 1 B.

Behaviour of Spores in 1 per cent. glucose water. Although many of the appearances just described can be quite well seen in a fresh preparation in saline, their significance can be brought out more distinctly by examining them in 1 per cent. glucose water and keeping them at room temperature for about three hours. One then notes that every sickle practically has undergone a change. Fig. 2 gives diagrammatically a rough idea of how the change takes place. The letter (*a*) shows a ripe normal sickle, (*b*) shows a slight enlargement of this, (*c*) shows a slight bulge ("fish embryo" appearance) on the concave side of the sickle, which contains at first a material devoid of granules.

The bulge becomes larger, the nucleus becomes indistinguishable, the sickle swells out, the granules appear to multiply and the protoplasm becomes vacuolated. The concavity now appears on the opposite side of the sickle owing to the horns being thrown back until finally a rounded form is reached at the stage (*f*). The sickle then bursts giving rise to an empty capsule (*g*), and a mass of vacuolated material containing a large number of granules. This latter mass disintegrates into free granules and débris as in (*h*). These granules would appear to be the final development of the sickle which produce new infections. The changes in the glucose water just described would appear to be an accentuation of a normal process for setting free the granules inside the muscle cyst rather than an actual cultivation on the sarcocyst. The sickles were tested in a considerable variety of media and in all of them with the exception of those containing glucose, they either remained unchanged or degenerated. The presence of glucose in the muscle may be significant in this connection.

Sections across normal ripe sarcocysts show that the central part of the cyst is in a state of so-called degeneration. It would seem however that, owing to the changes just described, the appearance of the sickle is altered, which transformation gives rise to this impression. Where in such cases the central part of the cyst is devoid of chromatin what in all probability has happened is that the sickles have matured, burst and scattered their granules. These granules have wandered possibly in an amoeboid form between the layers of spores, sporoblasts, etc., and have penetrated through the minute pores or cracks already described in the cyst wall to produce infections in fresh muscle cells.

Further development of the sarcocyst. The possible development of the sarcocyst to this stage having been considered, it must now be seen if there are any observations bridging over the gap between the small bodies above and the sarcocyst in the muscle as we usually find it. When these appearances were described by me the only observations I could find bearing on this point were those of Von Betegh and Dorcich (1912) who fed ducks on sheep sarcosporidia and found a development of the sarcosporidia in the muscle of the stomach. These early stages were very small and measured 4μ long $\times$ $3{\cdot}6\mu$ broad, although they consisted of three chromatin elements each surrounded by its protoplasm. Thus each chromatin granule would appear to be of about the dimensions of the granules shed from the burst sickle. Since that time however the observations of Erdmann (1914)[1] have thrown further light upon the subject and there can hardly now be any reasonable doubt that the bodies which invade the muscle fibres are small amoeboid forms of a size and form corresponding to the granules set free from the sickles as above described. (*Vide* Erdmann's paper, Pl. XVII.)

[1] Erdmann's paper in the *Sitz. Ber. d. Ges. naturf. Freunde. Jahrg.* 1910, No. 8, was not available to me.

VIII. Possible nature of Anaplasmata.

In an earlier paper (McGowan, 1913), it was suggested that these small bodies might pass part of their time between their escape from the cysts until their entry into new muscle fibres inside blood cells as Anaplasmata. Where Anaplasmata have been considered to be the actual cause of a disease, this has usually been some febrile condition often associated with Piroplasmosis and occurring in tropical or subtropical regions to which there would appear to be nothing corresponding in this country. One becomes curious therefore as to the significance of the frequency of these bodies in the red blood cells of animals in this country without febrile symptoms and without any indication of blood destruction and especially in sheep and mice which are known to be frequent harbourers of the sarcocyst. Some "Jolly" bodies are undoubtedly of the nature of a local concentration of material which when diffused gives the appearance of Polychromasia. This type occurs where blood destruction is going on, but as already mentioned these Anaplasmata occur where there is no evidence of this. Apart from this many of them are too well defined and resemble in their staining properties and otherwise so much the sarcosporidial granules that one thinks of a connection between the two almost instinctively.

IX. Mode of Infection by Milk.

In all probability the infection body in the milk is of the nature of these granules. Milk was frequently examined microscopically for their presence but in a fluid like milk it is almost impossible to be sure of the nature of any granules observed. Lanfranchi (1917) has shown that trypanosomes in some form or other can be conveyed from the mother to the young through the milk.

X. Intestinal Infection.

Such cases of infection by the milk, at least in regard to Sarcosporidiosis, would undoubtedly be by means of the intestinal canal and this leads up to a brief consideration of what is known regarding the *modus operandi* in this case. Theobald Smith (1901) was the first to describe this mode of transmission in the case of the mouse. Koch (1904) and Nègre (1907 and 1910) confirmed this observation. Nègre further believed that there must be an intestinal stage of the parasite, inasmuch as the faeces of mice which have eaten sarcosporidial flesh, are capable of infecting healthy mice from the fifteenth to the fiftieth or sixtieth day after their first feed. Negri (1908 and 1910) produced the disease by feeding white rats on the mouse sarcosporidium, and Darling (1910) produced it in guinea-pigs by feeding them on infected mouse flesh. Von Betegh and Dorcich (1912) and Erdmann (1910) have produced similar results. Erdmann describes a Schizont stage as taking place in the tissues of the intestinal canal. The schizonts take on an amoeboid form and invade the muscles. The question of sporogonous and schizogonous stages

are discussed by Erdmann but no conclusion is arrived at. Crawley (1916, 3) discusses what he believes to be the formation of gametes from the spores of *Sarcocystis muris* when ingested by the mouse. Some of the figures given by Crawley look like degeneration forms and Marullaz (1920) states that he has never found anything in his experiments which appeared to confirm Crawley's views regarding the fertilisation of the spores inside the intestinal cells.

The information therefore is fragmentary and none of it without considerable modification can be used to explain the method of transmission in the sheep. Crawley (1916, 379) suggests that dogs and carnivores eat the sheep and develop the Nègre forms in their faeces from which stage fresh sheep are infected by eating contaminated grass. Apart from what has already been mentioned this hypothesis will not hold good, at least in Scotland, where the opportunities of dogs and other carnivores eating raw mutton are very limited and where notwithstanding this practically every sheep harbours the sarcocyst.

XI. Summary.

A short description is given of an important disease of sheep (Scrapie, Traber-krankheit, La Tremblante), believed to be caused by a heavy infection with *Sarcocystis tenella*, probably of increased virulence.

The itchiness and paresis, the congenital transmission by the mother, the non-contagiousness, the long incubation period, etc., are readily explained on this view and a method of control of the disease based on this theory has been highly successful.

The sarcocyst has been shown to be transmitted from sheep to sheep by intrauterine infection and by means of the milk.

The minute structure of the sarcocyst is described and it has been shown in particular that the sickle-shaped spores are surrounded by a capsule. Under certain conditions, as in 1 per cent. glucose water and in the centre of the ripe cyst, these spores swell out and become globular, eventually bursting and scattering small chromatin granules. The further evolution of these granules is dealt with.

The spread by means of milk and by the intestinal route is discussed[1].

REFERENCES.

Alexeieff (1911). Sur la morphologie de la sarcosporidie du mouton (*Sarcocystis tenella*, Railliet), note préliminaire. *Compte Rendu de la Société de Biologie*, LXXI. p. 397.

—— (1912–13). Recherches sur les Sarcosporidies; étude morphologique. *Archives de Zoologie Expérimentale et générale*, LIII. 579.

Bertram (1892). Beiträge zur Kenntnis der Sarkosporidien nebst einem Anhange über Schlauche in der Leibeshole von Rotatorien. *Zoologische Jahrbuch, Anat. und Ontog.* v. 581.

[1] The characteristics of the disease itself are more fully discussed in my two previous papers, namely, in An Investigation into Scrapie, a bulletin of the Edinburgh and East of Scotland College of Agriculture published in 1914 and in the *Scottish Journal of Agriculture*, vol. v. no. 4, 1922, p. 363.

Von Betegh (1909). Beiträge zum Entwicklungsgang der Sarkosporidien. *Centralblatt für Bakteriologie*, LII. 566.

Von Betegh and Dorcich (1912). Studien ueber Sarkosporidien. *Centralblatt für Bakteriologie*, LXIII. 387.

Crawley (1916). The sexual evolution of *Sarcocystis muris*. *Proceedings of the Academy of Natural Science of Philadelphia*, LXVIII. 3.

Crawley (1916). The zoological position of the Sarcosporidia. *Ibid.* 379.

Darling (1910). Experimental Sarcosporidiosis in the guinea-pig. *Journ. of Exper. Medicine*, XII. 19.

Erdmann (1910). Beiträge zur Morphologie und Entwicklungsgeschichte des Hammelsarkosporids in der Maus. *Central. für Bakteriologie*, LIII. 510.

—— (1914). Zu einigen strittigen Punkten der Sarkosporidienforschung. *Arch. de Zool. Expér. et génér.* LIII. 579.

Koch (1904). Die experimentale Uebertragung der Miescherschen Schlauche. *Berliner Klinische Wochenschrift*, XLI. 321.

Lanfranchi (1917–18). Sur la possibilité du passage des trypanosomes dans le lait. *Archives Italiennes de Biologie*, LXVIII. 158.

Laveran and Mesnil (1899). Sur la morphologie des Sarcosporidies. *Compte Rendu de la Soc. de Biol.* XLVII. 245.

Marullaz (1920). Sur l'évolution de la *Sarcocystis muris*. *Annales de l'Institut Pasteur*, XXXIV. 547.

McGowan (1913). Note on Anaplasmosis. *Journal of Path. and Bacter.* XVIII. 130.

—— (1914). Investigation into Scrapie. *Bulletin of Edinburgh and East of Scotland College of Agriculture*. Blackwood, Edinburgh.

Minchin (1912). *An Introduction to the Study of the Protozoa*. Arnold, London.

Nègre (1907). Sarcosporidiose Experimentale. *C. R. de la Soc. de Biol.* LXIII. 374.

—— (1910). Sur le stade Intestinale de la Sarcosporidie de la Souris. *Ibid.* LXVIII. 997.

Negri (1908). Beobachtungen ueber Sarkosporidien. *Centralblatt für Bakteriologie*, XLVII. 56 and 612.

—— (1910). Beobachtungen ueber Sarkosporidien. *Ibid.* LV. 372.

Perret (1909). Contribution a l'étude des poisons des Actinies. *Travaux du Laboratoire de M. Ch. Richet*, VI. 288.

Richet (1909). Notes sur la Thalassine, poison pruritogène, contenu dans les tentacules des actinies. *Ibid.* VI. 384.

Smith Theobald (1901). The production of Sarcosporidiosis in the mouse by feeding infected muscular tissue. *Journal of Exper. Med.* VI. 1.

—— (1905). Further observations on the transmission of *Sarcocystis muris* by feeding. *Journal of Medical Research*, XIII. 439.

Teichmann (1911). Ueber die Teilungen der Keime in der Cyste von *Sarcocystis tenella*. *Archiv für Protistenkunde*, XXII. 239.

A REFERENCE LIST OF THE TREMATODE PARASITES OF BRITISH BIRDS.

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INTRODUCTION.

As a subject of investigation the Trematode fauna of British Birds does not appear to have aroused at any time much enthusiasm amongst British zoologists and as a result we owe the greater part of our knowledge of the subject to continental workers. The fact that our bird fauna is practically identical with that of the adjacent parts of Western Europe would lead us to expect that the parasites of our birds should not differ materially from those met with in the same species of birds on the continent. As a matter of fact, no species of bird Trematode hitherto recorded from this country can be regarded as peculiar to Britain, with the possible exception of *Echinostephilla virgula* Lebour, which, however, will almost certainly be met with in other localities later.

It is not to Western Europe alone, however, that our bird fauna is confined, for not only are most British birds widely distributed throughout Europe and the temperate parts of Asia, but many of the migrant species spend part of their time in the more tropical regions of Asia and Africa. Moreover, in not a few instances the distribution, natural or otherwise, is not confined to the old world but extends to the Arctic regions, to America, and even to Australasia. It may thus happen that the species of birds occurring in this country acquire some of their parasites in countries distantly removed. It is in any case more than probable that certain of these parasitic infections are acquired outside the British Isles and that such parasites do not complete their life-cycle within the British area. This is a supposition, however, which, with our present meagre knowledge of life-histories, is supported by few actual facts.

Speaking generally the distribution of a particular Trematode parasite may be regarded as determined by the distribution (1) of its final host, (2) of its intermediate host or hosts. In certain cases all stages may be met with in a circumscribed locality (*e.g.* "*Echinostomum secundum*" on the Northumberland

coast). In other cases one may look in vain for intermediate stages in the locality in which the bird was captured. This statement may be regarded as a certainty in the case of parasites of birds which rarely or only occasionally visit this country but it may also prove to be true in the case of many parasites of the more common migrant birds.

The specificity, in varying degree, of parasites towards their hosts applies not only to the final hosts but to the intermediate hosts as well and while we know that the larval stages of Trematodes can and do, under certain circumstances, adapt themselves to different hosts in altered environment it is highly probable that such alterations and adaptations are not, frequently or to any great extent, immediately successful. This matter is well illustrated by recent observations on the highly specialised Schistosome parasites of man, which until a few years ago were believed to have an almost exclusively tropical and sub-tropical distribution. The discovery of *indigenous* cases in Southern Europe and elsewhere in the temperate zones has demonstrated that these parasites can establish themselves in favourable localities but it must be noted that these localities were provided with suitable intermediate hosts (*i.e.* molluscs nearly related to the original intermediate hosts) and that the environment was to some extent artificially abnormal. It is, however, not improbable that the Schistosome parasites, which occur in several species of European birds, may complete their life-cycle within the temperate zone. This is a circumstance which might have enabled the problem of human bilharziasis to have been solved experimentally some years before it actually was and it is of interest to note here that, as a result of his researches on other blood Trematodes, Odhner in 1911 practically predicted the discovery of the cercarial mode of infection (instead of the miracidial mode of Looss) in the case of human bilharziasis, thus affording yet another instance of the great value of comparative pathology to human medical science.

The problems connected with life-histories are amongst the most fascinating and probably the most difficult in helminthology and they undoubtedly promise the most fruitful results in further research. In the past we have to a large extent been content to accept a limited number of classical investigations, dealing mainly with *Fasciola hepatica*, as providing sufficient material for our knowledge of this subject, but the remarkably interesting results achieved by the few workers who have devoted attention to this branch of experimental biology have demonstrated the occurrence of many variations, a knowledge of which cannot fail to be of general biological interest and importance. The possible permutations in the life cycle, from the ovum to the adult worm, are of considerable number and several of the theoretically possible life-cycles have been demonstrated in actual occurrence. The discovery of the cutaneous route of infection in the case of Trematodes has added further complexity to a subject, already one of the most complex in general zoology.

It is not my purpose to enter into the subject of life-histories or intermediate hosts in this paper which is intended merely as a record of the

Trematodes found in birds but it is obvious that in an exhaustive account of the subject such details would be necessary. So far as regards British larval Trematodes, including those of birds, the most important works on the subject are those of Lebour (1912) and Pelseneer (1906). The work of the former is of great interest and must be classed amongst the best which has been done on the subject. Such work is undeniably tedious and involves a high degree of technical skill as well as a thorough knowledge of invertebrate, particularly molluscan, biology. The earlier work of Sonsino on the same subject in Egypt has been brought into prominence by Leiper's researches on *Bilharzia*.

Apart from the subject of life-histories, which is outside the scope of this paper, the main matters to be considered are the structure and classification, the distribution and the bionomics of these parasites. These matters have but rarely been considered separately so that it will serve no useful purpose to endeavour to dissociate them in the present instance. In papers such as those on the bionomics of helminths (Nicoll, 1910) and the zoogeographical distribution of worm parasites (S. J. Johnston, 1914) one may find a brief general *résumé* of such facts as are available on these subjects.

In dealing with systematic and descriptive work one must take into consideration the date at which it was published and the current state of knowledge and opinion at the time. Helminthology as an exact science may be taken to date essentially from the time of Rudolphi (1808–1819[1]) who, fortunately, was an exact and careful observer and who, still more fortunately, made an extensive collection, the types in which have for the most part been preserved. The fact that Rudolphi, in addition to being a master of his subject, had an almost untouched field, with few competitors, has had the result that as a discoverer or namer of new species he has no modern rival in the field of European bird Trematodes.

The increased power of differentiation afforded by modern microscopical appliances has resulted in the discovery and elucidation of details which were impossible of study in Rudolphi's time. His *Historia naturalis* (1808) and his *Synopsis* (1819), nevertheless, constitute the two most important fundamental works in systematic Helminthology and in these he describes a large number of bird Trematodes of which about forty belong to the British fauna.

Over twenty years elapsed before the appearance of the next helminthologist of any standing, namely Creplin (1829–1849). He formed a considerable helminthological collection, including much material from birds. Of species pertaining to the British fauna he named and described about twenty. Creplin, however, was overshadowed by Diesing (1836–1858) who followed him and who summarized the results of helminthological investigations up to that date in his *Systema Helminthum* (1850). This marked the culminating point of the work of the early systematists. Diesing's contemporary Dujardin wrote an entertaining *Histoire des Helminthes* (1845) but its scientific value is in many

[1] The dates in brackets represent the period during which the author dealt particularly with the Trematode parasites of Birds.

respects inferior to that of Diesing's work. The period immediately following Diesing was probably the most unproductive in work of a systematic character so far at any rate as it affected our knowledge of the Trematode parasites of birds.

The systematic work of von Linstow (1873–1906) was by far the most important in what may be considered a transitional period, remarkable much more for its discoveries on the experimental and pathological sides than on the systematic side. As a systematist von Linstow enjoyed a longer period of supremacy than has any other helminthologist, but his most useful contribution to helminthology is undoubtedly his *Compendium* (1878 and 1889), the forerunner of the more modern (American) bibliographical work, and a publication which even now has not outlived its usefulness. Between von Linstow and the present school of helminthologists the most outstanding names were those of Brandes (1888–1892), Stossich (1892–1905) and, in particular, Braun (1893–1902).

The present epoch may be regarded as dating from 1899, the date of appearance of Looss's *Weitere Beiträge*. Looss's influence (1896–1907) on helminthology is probably greater than that exerted by any worker since Rudolphi but so far as European bird Trematodes are concerned the work of Jägerskiöld (1898–1908) and Odhner (1900–1914) is of more immediate importance. The work of these three zoologists represents the highest level to which systematic investigations on the Trematode parasites of birds have attained and their work in conjunction with that of Braun and of Lühe (1898–1909) forms the basis of our present knowledge of the subject. Of the younger school of helminthologists, those who have devoted most attention to the matter of bird Trematodes are Dietz (1909–1910), Kossack (1911) and Skrjabin (1912–1916).

From the foregoing it is apparent that we owe the greater part of our knowledge of the Trematode parasites of British birds to continental zoologists, but the work of Lebour (1909–1922) and myself (1906–1915) has demonstrated that a not inconsiderable number of forms are either peculiar to Britain or —more probably—had not previously been recorded in other parts of Europe. For instance, two of the more aberrant forms of the Echinostome family, namely *Echinostephilla virgula* Lebour and *Parorchis acanthus* Nicoll, have not yet been recorded elsewhere in Europe, though Linton's *Parorchis avitus* has been described in America. This raises the question of the geographical distribution of these parasites, a subject not only of interest but also probably of some economic importance. In view of the present incomplete state of our knowledge, however, and of the questionable authenticity of many records it is doubtful if any good purpose would be served by detailed tabulation of the localities in which certain parasites have been recorded in certain hosts. In the first place we may take it that in the case of migratory birds their parasites will be *liable* to be found throughout the whole area of migration in any particular case, and in the case of a widely distributed migrant certain parasites will be found to be cosmopolitan in distribution, *e.g. Echinostomum revolutum*, which has been recorded not only in Europe and America but also in Australia.

On the other hand, in the case of non-migratory birds having, however, a wide range of distribution we find that closely related species of the same genus of parasites may evolve in widely separated localities. While such evolution of new species in a distinct variety or sub-species of bird host may be influenced to some extent by the alteration in the bird host it seems more likely that the evolution or alteration may be induced by the necessity imposed upon the larval parasite of seeking a new and strange intermediate host in the new locality. In other words, where the distributions of the final (bird) and intermediate (invertebrate) hosts are not coterminous a different species may serve as intermediate host in certain localities. But it must not be overlooked that just as the mature parasite may have a more or less extensive variety of final hosts, so the larval stages may also parasitize indiscriminately a number of different intermediate hosts, some of which may be present in one locality and some in another. This matter appears to be well illustrated by the above-mentioned investigations on the life-history of the *Bilharzia* worms, for which at least two considerably different species of mollusc serve as intermediate hosts. It has been asserted that the larvae from one species of invertebrate host give rise to adults with lateral spined eggs, whereas the larvae from the other intermediate host produce adults of the same species with terminal spined eggs. The trend of opinion, however, seems to favour the view that these adults represent two distinct, though morphologically similar, species.

We may pass now to consideration of a matter best illustrated perhaps by reference to the succeeding lists, namely the distribution of the various parasites throughout the avian fauna. At a casual glance it is apparent that while some birds appear to be immune to infection with Trematode parasites, and some to be subject to at most one species, there are others which may harbour a dozen or even twenty different species of parasite. One has only to compare, for instance, the list of parasites of Passerine birds (excluding the Corvidae) with that of the gulls, or again the list of gallinaceous birds with that of the ducks, to be struck with the great disparity in the range and variety of their parasites. Moreover, within the Passerine group there is obviously a great difference between the parasites of the Corvine birds and those of the remaining Passerines. From only a general knowledge of the feeding habits of these various groups of birds it is apparent that the facts are to some extent correlated with a vegetable diet on the one hand and an animal diet on the other. Such a generalisation, like most, is not by any means of universal application for one has only to think of the extraordinary proneness to Trematode infection of the herbivorous mammals; though in this case it must be added we are dealing with one of the great exceptions in Trematode bionomics.

In the second place it may be noted that while certain species of parasite occur with great frequency in a large variety of hosts, others appear to be rare or to be specific for one or at most a few hosts. In the first category the most outstanding examples are the Monostomes, *Notocotylus attenuatus* and *Catatropis verrucosa*, one or both of which live in a very large variety of different

birds. In spite of their commonness or, perhaps, because of it, these two species have been repeatedly confused with each other and it is thus practically certain that the existing records of these species are in many cases erroneous. The Holostomes, again, particularly *Strigea strigis*, *S. erratica* and *S. variegata*, are exceedingly common parasites of the birds of prey, the ducks and the gulls respectively, while the Hemistomes, *H. spathula* and *H. pileatum*, are almost equally common parasites respectively of the hawks and gulls, but strangely enough no species of this genus has ever been recorded from any of the ducks, with the exception of one doubtful record from the goosander. This is a fact which is evidently correlated with some fundamental difference in feeding habit or constitution between gulls and ducks.

Of the true Distomes by far the most widely distributed is *Prosthogonimus ovatus* which inhabits the Bursa Fabricii of a large variety of birds, more than half of which, however, are either Passerine or wading birds. The closely allied and frequently confused *Prosthogonimus cuneatus* shows an even greater predilection for the Passerines. Another parasite which exhibits a definite preference for the Passerines is *Leucochloridium macrostomum*, while the two commonest Echinostome parasites, *Echinostomum revolutum* and *Hypoderaeum conoideum*, are almost entirely confined to the Anseriform kinds (ducks, etc.). The commonest of the "Monostome" parasites, *Collyriclum faba*, is exclusively a Passerine parasite.

Now there is one feature which is shared by almost all these common parasites, namely a peculiarity of habitat in their hosts, for while by far the larger number of Trematodes live actually in the intestine proper of their hosts the above-mentioned species have all an "abnormal" or unusual habitat. For instance, *Notocotylus* and *Catatropis* are essentially parasites of the coeca though they are not infrequently met with in the adjacent part of the intestine. The species of *Prosthogonimus* are essentially parasites of the peculiarly modified part of the intestine, known as the Bursa Fabricii. *Leucochloridium* is commonest in the cloaca, while the majority of Monostomes inhabit the air sacs. The Monostome, *Collyriclum faba*, perhaps the most remarkable of all bird Trematodes in its choice of habitat, lives in cysts under the skin. In view of this almost unique habitat it is not surprising that Odhner has sought for, and apparently found, the nearest relative of this parasite in the well-known lung fluke, *Paragonimus*, and his choice of the name *Troglotremidae* to designate the family, is remarkably apt.

Of all the commoner parasites, therefore, the only species which are true intestinal parasites are the Holostomes and *Echinostomum revolutum* and even they show a decided preference for the lower end of the intestine and the rectum.

The true liver-flukes of birds, which belong to the two families Opisthorchiidae and Dicrocoeliidae, bear close resemblance to their mammalian relatives. Of the first-named family about a dozen different species are believed to occur in British birds, the best known being probably *Metorchis xantho-*

somus and *M. crassiusculus*, but the group also includes the remarkable aberrant form, *Pachytrema calculus*, described by Looss from the gall-bladder of the black-headed gull. The Dicrocoeliid family contains a larger number of representatives in British birds, although several of them are rather doubtful species. None of them are so well known as the above-mentioned *Metorchis* species. The best-known of them are *Lyperosomum longicauda*, the common liver-fluke of crows, and *Athesmia heterolecithodes*, the peculiar liver-fluke of the moorhen (*Gallinula chloropus*).

Another well-marked group with characteristic habitat is formed by the Clinostomes, which live chiefly in the mouth and upper end of the oesophagus and trachea. Their nearest relatives, the Harmostomes, are true intestinal parasites.

The only kidney parasite, hitherto described from a British bird, is the uncommon *Renicola pinguis* of Mehlis from the crested grebe. Here again we are dealing with a parasite of unusual habitat, and we have therefore to seek its affinities in unusual types. As a matter of fact Odhner again sees in this aberrant form another possible member of his family Troglotremidae, though structurally it appears to me to possess a closer resemblance to the Gymnophalline group. This latter group furnishes an excellent illustration of the lines along which change of habitat may have taken place. Of the ten species of the genus, recorded here, four live as ordinary intestinal parasites in the scoter duck. One, *Gymnophallus somateriae*, lives both in the intestine and the coeca. *G. dapsilis* lives in the intestine and the Bursa Fabricii. *G. bursicola* lives chiefly in the Bursa, while three species, *G. choledochus*, *G. deliciosus* and *G. micropharyngeus*, are parasites of the gall-bladder. It is obvious that more than half of this genus of parasites have deserted the intestine proper for more secluded habitats in the gall-bladder, coeca and Bursa Fabricii, but at the same time in each of these situations they are in more or less intimate connection with the intestine proper. It appears to me not impossible that *Renicola pinguis* may represent an abnormal Gymnophallid, originally a cloacal parasite, which has migrated up the ureters and found a congenial habitat in the pelvis of the kidney. This parasite, however, has only been rarely observed and, in view of our slight acquaintance with it, it seems unwise to speculate too unreservedly on its possible affinities. Odhner eventually concludes that the Troglotremidae display most affinity with the Heterophyidae, a conclusion which appears eminently reasonable. *Gymnophallus*, however, also displays affinities with the Heterophyidae and it appears to me that *Renicola* is more closely related to this genus than to the Troglotremidae.

The subject of avian Bilharziasis has been already referred to and it is one which is of considerable zoological interest. The Bilharzias are certainly the most highly specialised of all Trematodes not only in their habitat but also in their structure. These forms have been dealt with by a number of observers, including Looss, Braun, Kowalewski, Parona and Ariola and particularly Odhner (1912). Although no record has been made of their occurrence in birds

in this country I may note here that I personally found *Gigantobilharzia acotylea* Odhner (1910) in the abdominal veins of the black-headed gull at St Andrews in 1906, though it was not until the publication of Odhner's work that I realised the nature of the parasite.

The occurrence of two or more different species of a genus in the same host and at the same time has frequently caused much confusion and has been responsible for not a little intricate synonymy. It is, however, nowadays a matter of common observation that many birds and other animals may be parasitised by two, or more, closely similar species of the same genus. *Prosthogonimus ovatus* and *P. cuneatus* form a case in point. Cases in which *three* closely similar parasites inhabit the same host are much less frequent, but we find three different species of *Strigea* recorded from *Clangula hyemalis*, *Oidemia fusca* and *Larus ridibundus* and as many as four from *Anas boschas*. The Strigeas, however, are difficult species to diagnose without the most careful examination and I feel convinced that many superficial diagnoses have been made in error. This opinion is evidently shared by Lühe who gives very restricted lists of satisfactorily authenticated records of these parasites. In the lists which I submit here the records are given as they stand, but it must be distinctly understood that in perhaps the majority of cases they require strict revision.

Again, the three species of *Cyclocoelum* recorded from the curlew, *Numenius arquata*, appear to need revision, although the two described by Stossich are probably authentic and distinct.

In *Totanus ochropus* we find three species of *Echinoparyphium* all described by Skrjabin in the same locality. Without, however, desiring to comment on the validity of Skrjabin's work it seems to me that these three species require further re-examination.

In a different category are the three species of *Gymnophallus*, met with in the eider-duck (*Somateria mollissima*), which are well authenticated by Odhner. The most outstanding case, however, is that of the common scoter (*Oidemia nigra*) from which as many as seven different species of *Gymnophallus* have been recorded. Two of these occur also in the eider, but the other five are, so far, peculiar to the scoter. Four of these species were discovered by Jameson and Nicoll (1913) in the course of experimental investigations on the subject of pearl production, though the birds in which the parasites were obtained were not experimentally infected.

Instances of the occurrence of such a large number of species of one genus in the same host are not common in regard to Trematodes, but, to mention only a few familiar instances, we find that at least seven species of the tapeworm genus *Hymenolepis* have been recorded from the common duck and as many as eleven from the scaup (*Nyroca marila*), while, again, ten species of the Nematode genus *Cyathostomum* are recorded by Looss from the ass and a dozen of the same genus from the horse. These records are all based on natural infection but certain experimental results must be taken into consideration.

Thus it has been found that, in experimentally infecting dogs with *Clonorchis sinensis*, worms of much smaller than normal size were produced resembling, however, in all other respects the normal species in man (Leiper). While it may be conceived that such "experimental" infections are continually taking place in nature it is certain that the results of artificial experiments do not explain or account for the coincident occurrence of several closely related forms in the same host at the same time. That such multiple species merely represent varieties or different developmental stages of the same species *might* be advanced as a possible hypothesis, but such is entirely opposed to the facts of the case.

The distribution of the commoner Trematode parasites amongst the various classes of birds may be roughly exhibited in the following table in which the figures indicate the number of different hosts in each group of birds in which the particular parasite has been recorded:

	Passeres	Striges	Accipitres	Anseres	Charadrii	Lari	Colymbi	Ralli
Notocotylus attenuatus	—	—	—	21	2	—	—	4
Catatropis verrucosa	—	—	—	21	2	—	—	3
Strigea strigis	1?	7	11	—	—	—	—	—
Strigea erratica	—	—	—	10	3	—	2	—
Strigea variegata	—	—	1?	3?	—	8	3	—
Hemistomum spathula	—	4	12	—	1?	—	—	—
Prosthogonimus ovatus	9	1	3	—	5	2	1	3
Echinostomum revolutum	—	—	1?	13	2?	—	1?	—
Leucochloridium macrostomum	10	—	—	—	1	—	—	3
Collyriclum faba	12	—	—	—	—	—	—	—

Reference to the systematic section of this paper will show that nearly a sixth of all the *named* species of British bird Trematodes are, if not actually *nomina nuda*, so imperfectly described that it is impossible to assign them definitely to any genus or to specify, otherwise than broadly, their systematic position. Most of these are old creations of Rudolphi, Mehlis or Creplin, of which the types, if still extant, are imperfectly preserved and the descriptions entirely inadequate for identification. In a certain number of cases, however, it is probable that further investigation of either already existing material or fresh material from the same hosts may result in furnishing us with a more accurate account of these forms. In regard to a minority of these species we possess fairly reliable descriptions though no success has hitherto attended any attempt to assign them a generic position. Finally, not a few of these specific names will probably be found to be synonyms of species already known under another name, but this can only be decided by re-examination of the original types.

The records in the following lists are given as they were published by their original observers, with such modifications as have been definitely and satisfactorily made by later workers. No attempt has been made to add to this except in cases presenting conflicting opinions, in which a definite decision, one way or another, was necessary. In this connection the opinions of such

authorities as Looss, Odhner and Jägerskiöld have *generally* been considered to outweigh those of earlier or less experienced workers.

On examining the lists it will be found that in the case of considerably over a hundred birds (116) no Trematode parasites have yet been recorded, while in an additional 53 only a single species has hitherto been found. On the other hand, the common scoter (*Oidemia nigra*) establishes a record with a quota of 22, its nearest rival being the common wild duck with 17, while the scaup (*Nyroca marila*), the long-tailed duck (*Clangula hyemalis*) and the herring gull (*Larus argentatus*) come next with 16 each. The average quota may be taken as about 3.

The most recent compendium of bird Trematodes is that of Lühe in *Die Süsswasserfauna Deutschlands*, but as it deals only with such birds as frequent inland waters its scope is correspondingly restricted. Thus the list refers to only 92 species, or less than a third of the number of British birds. For a complete compendium we have to go back as far as 1873–1889, the dates of von Linstow's *Compendium* and *Supplement*. When we consider the extensive additions and alterations which have been effected during the intervening years and the greatly changed aspect of Helminthology as a whole it is not surprising to find that von Linstow's *Compendium* contains less than one-half of the records which are now available. This in itself would be quite sufficient to justify the appearance of a revised reference list, quite apart from the fact that in von Linstow's work all species are listed under the obsolete generic names Distomum, Monostomum, etc., and that the references cited are to a large extent out of date and replaceable by others more modern and more suitable. Reference to von Linstow, however, will always be found useful when dealing with the older literature.

It is particularly amongst the ducks, waders, gulls and divers, *i.e.* the marine or seashore birds, that the principal increases in our records have occurred and this undoubtedly is to a large extent due to the work of Jägerskiöld and Odhner. The approximate relative increases in the case of the chief classes of birds may be summarised as follows:

	Number of Records up to	
	1889	1922
Anseriformes (ducks, etc.)	123	257
Charadriiformes (waders)	45	115
Passeriformes (sparrows, crows, etc.)	66	115
Lariformes (gulls, etc.)	39	83
Ardeiformes (herons)	38	71
Accipitriformes (hawks)	40	68
Colymbiformes (divers)	12	41
Ralliformes (water-fowl)	20	40
Strigiformes (owls)	18	24
Pelecaniformes (pelicans, etc.)	6	14
Coraciiformes (swallows, etc.)	6	13
Alciformes (auks, etc.)	8	12
Others	5	19

Owing to the occurrence of doubtful records and identifications these figures can only be regarded as approximate.

There remain a few matters of systematic and nomenclatural importance or interest which may be briefly referred to here. Without wishing or presuming to enter into nomenclatural controversies I must indicate in some measure the lines which have been followed in dealing with the taxonomic part of this paper.

In dealing with or establishing a monotypical genus it appears to me absurd to give a so-called "generic diagnosis." The necessary and sufficient thing to me appears to be to show reason why such species cannot be included in or with any already existing genus or generic type. To select from the specific description of a species such features as *shall* or *will* constitute the more or less restricted definition of its genus appears to me to demand either prophetic genius on the one hand or dogmatic assurance on the other. Even where two or more species apparently or obviously conform to the same type it seems to serve little useful purpose to select a hard and fast generic diagnosis, for it is a frequent experience that such "definite" genera require later to be modified either in a wider or stricter sense. On the other hand, a provisional diagnosis may be convenient for reference but such diagnosis should be construed in the most flexible (though not loose) sense. In these matters I must confess I prefer to follow the opinions of such authorities as Looss and Odhner rather than those of the archaeohelminthologists.

Insistence on the existence of "type-specimens" of helminth species seems to me to be of far less *general* importance than the existence of proper and sufficing descriptions. To the average scientific worker such descriptions are generally more or less readily accessible but the same can assuredly not be said with regard to type-specimens. Another, though minor, point in the problem of specific type-preservation is the possibility of mixing of specimens which might occur even in the most meticulous of museums. An illuminating illustration of this is contained in Odhner's sarcastic communication on *Dicrocoelium dendriticum* as the correct name of the lesser human liver-fluke (*D. lanceolatum* Rud. *vel lanceatum* St. and H.). One could wish for no more convincing proof of the possible futility of undue reliance on "type-specimens."

The extreme height of this folly, however, is exposed by Odhner in his acceptance of Looss's generic names *Lasiotocus* and *Pristisomum* (*in manuscript*), the one founded on an already described species (*Distomum mulli* Stossich), the other on two *named* but *undescribed* species, the type-specimens of which are presumably preserved in Looss's private collection, wherever that may be. For my part I prefer Looss's more usual method of exhaustive description. At the same time one could welcome a universal type collection or several national collections, to which types could be sent and where there would be some assurance of proper care and accessibility. On the other hand, the vicarious deposition of type specimens in haphazard museums or collections is probably in most cases worse than useless.

To define a genus with the implication that all its species must have this feature and must not have that is to introduce an artificiality which cannot

fail to be opposed to any system of *natural* classification. In this respect the work of Odhner may be taken as an excellent guide. To insist that our acceptance of such work must be contingent on the production or deposition of a collection of perishable type-specimens is in my opinion more than absurd.

What constitutes a sufficient or proper specific diagnosis is of course a difficult problem and there is an immeasurable distance between the ridiculously inadequate "diagnoses" of, say, Stafford on the one hand and those of Looss on the other. To my mind, however, it would not be impossible or even difficult to set a more or less flexible standard of competent diagnosis, such in fact as is *tacitly* set by the work of the best systematists. While it is true that few helminthologists have attained the technical skill of Odhner, Looss or Jägerskiöld, it is equally true that the majority can, if they so desire, attain a degree of ability sufficient for all practical purposes. The work of such so-called systematists who cannot or will not attain even this moderate standard could, in my opinion, be ignored with the greatest benefit to helminthology and to science in general. I fail to see why work in a subject of such great economic importance as helminthology should be hampered and retarded by the futile efforts of a few incompetents.

Speaking again from a practical and economic standpoint the work of the over-zealous archaeologists cannot fail to have a disastrous effect in economic and medical helminthology. In medical science the use of the binomial *Trichuris trichiurus*, for instance, in place of the more familiar and more descriptive name, *Trichocephalus dispar*, is not only misleading but regrettable though I admit it is no more difficult to induce a class of students to think and speak of the animal in one phraseology as in another. It is welcome, however, to find Stiles advocating modification of the strict laws of nomenclature in the case of such species as are of importance and interest in the economic sciences and I venture to think that this principle is worthy of a much more extended application, *e.g.* in the names of species which form the subjects of instruction in elementary or advanced classes of Biology.

The much disputed point as to whether Linnaeus or Rudolphi shall be accepted as the starting-point in helminthological nomenclature is worthy of the greatest consideration. In Rudolphi we have the first and perhaps the greatest of all systematic helminthologists. Pre-Rudolphian helminthology is to a large extent both sketchy and inaccurate and much of it is now matter for conjecture. Rudolphi was admittedly a master of his subject and it seems to me that his conclusions might well be accepted as final in the matters on which he treats, apart from the cases in which he deliberately altered an already existing name to one of his own coining. This presumably was done by him to secure terminological uniformity and I hardly think that much injustice would be done to pre-Rudolphian helminthologists by ignoring names which were in many cases not intended for systematic purposes. While therefore it may be reasonable to revert to the older names of such species as Rudolphi deliberately renamed and redescribed there seems little reason for disinterring names, the validity of which can only be substantiated by circumstantial evidence.

In the subjoined systematic list no attempt is made to introduce new or personal ideas into the system of classification. Apart from the natural desire to arrange all known species in some systematic order in relation to each other no liberties have been taken with existing ideas on the subject. On that account unless a species has for one reason or another been "classified" by some responsible authority it has in the present list been assigned to the unclassified groups, even in spite of the fact that I may entertain personal opinions on its probable position in the system. In cases where conflicting opinions have been expressed I have naturally exercised my own judgment; but, as in many cases equally reasonable but divergent opinions prevail, it follows that in such cases the choice may be more a matter of convenience than of conviction.

The names *Distomum*, *Monostomum* and *Holostomum* are used in the sense of group names in the case of species which have not yet been definitely assigned generic position.

LIST OF THE TREMATODE PARASITES RECORDED FROM BRITISH BIRDS, ARRANGED SYSTEMATICALLY[1].

Order **DIGENEA.**

Super-family DISTOMATA Retzius.

Family PSILOSTOMIDAE Odhner 1913.

Sub-family *Psilostominae* Lühe 1909.

Genus *Psilostomum* Looss 1899

1. P. brevicolle (Creplin) — Braun 1902, Odhner 1913
   [=P. platyurum Mühling]

Genus *Psilotrema* Odhner 1913

2. P. spiculigerum (Mühling) — Mühling 1898, Odhner 1913
3. P. simillimum (Mühling) — Mühling 1898, Odhner 1913
4. P. oligoon (v. Linstow) — v. Linstow 1887, Braun 1902

Genus *Psilochasmus* Lühe 1909

5. P. oxyurus (Creplin) — Braun 1901, 1902, Odhner 1913
6. P. longicirratus Skrjabin — Skrjabin 1913 *a*

Genus *Sphaeridiotrema* Odhner 1913

7. S. globulus (Rud.) — Braun 1902, Odhner 1913

Genus *Apopharynx* Lühe 1909

8. A. bolodes (Braun) — Braun 1902, Odhner 1913

Sub-family *Orchipedinae* Skrjabin 1913.

Genus *Orchipedum* Braun 1902

9. O. tracheicola Braun — Braun 1901 b, 1902
10. O. turkestanicum Skrjabin — Skrjabin 1913 *a*, *b*

Family ECHINOSTOMIDAE Dietz 1910.

Sub-family *Echinostominae* Odhner 1910.

Genus *Echinostomum* Rud. 1809

11. E. chloropodis (Zeder) — Diesing 1850, Dietz 1910
    [=E. uncinatum (Zeder)]

[1] Species marked * occur *only* in birds which are rare or, at most, occasional visitors to the British area.

Genus *Echinostomum* Rud. 1809 (*continued*)

12.	E. paraulum Dietz	Dietz 1909, 1910
13.	E. revolutum (Froelich) [=E. echinatum Zeder]	Dietz 1910, Johnson 1920
14.	E. mesotestius Solowiow	Solowiow 1912
*15.	E. nephrocephalum (Diesing)	Looss 1899, Dietz 1910
16.	E. stridulae (Reich.) [=E. apiculatum Rud.]	Looss 1899, Dietz 1910
17.	E. echinocephalum (Rud.)	Looss 1899, Dietz 1910
18.	E. liliputanum Looss	Looss 1896, Odhner 1910 *a*
19.	E. exechinatum Solowiow	Solowiow 1912
20.	E. sarcinum Dietz	Dietz 1909, 1910
21.	E. anceps (Molin)	Molin 1859 *b*, Dietz 1910
22.	E. limicola J. C. Johnson	Johnson 1920
23.	E. uralense Skrjabin	Skrjabin 1915 *a*
24.	E. academicum Skrjabin	Skrjabin 1915 *a*
25.	E. echiniferum La Valette	La Valette 1855, Wolffhügel 1900
*26.	E. magniovatum Stossich	Stossich 1898 *b*, Looss 1899
27.	E. pungens (v. Linstow)	v. Linstow 1894, Looss 1899

Genus *Echinoparyphium* Dietz 1909

28.	E. agnatum Dietz	Dietz 1909, 1910
29.	E. aconiatum Dietz	Dietz 1909, 1910
30.	E. recurvatum (v. Linstow)	v. Linstow 1873, Dietz 1910
*31.	E. elegans (Looss)	Looss 1899, Dietz 1910
32.	E. politum Skrjabin	Skrjabin 1915
33.	E. mordwilkoi Skrjabin	Skrjabin 1915
34.	E. clerci Skrjabin	Skrjabin 1915
35.	E. baculus (Diesing)	Dietz 1910

Genus *Patagifer* Dietz 1909

36.	P. bilobus (Rud.)	Dietz 1910, Odhner 1910 *a*

Genus *Nephrostomum* Dietz 1909

*37.	N. ramosum (Sonsino)	Dietz 1910, Odhner 1910 *a*

Sub-family *Himasthlinae* Odhner 1910.

Genus *Himasthla* Dietz 1909

38.	H. militaris (Rud.) Dietz	Dietz 1910
39.	H. leptosoma (Creplin)	Dietz 1910, Odhner 1910 *a*
40.	H. rhigedana Dietz	Dietz 1909, 1910
41.	H. elongata (Mehlis)	Diesing 1850, Dietz 1910

Genus *Acanthoparyphium* Dietz 1909

*42.	A. phoenicopteri (Lühe)	Lühe 1898, Dietz 1910
*43.	A. spinulosum S. J. Johnston	S. J. Johnston 1917

Genus *Chloeophora* Dietz 1909

44.	C. micata Dietz	Dietz 1909, 1910

Genus *Pelmatostomum* Dietz 1909

45.	P. episemum Dietz	Dietz 1909, 1910

Sub-family *Echinochasminae* Odhner 1910.

Genus *Echinochasmus* Dietz 1909 [=Episthmium Lühe]

46.	E. bursicola (Creplin) Stiles	Dietz 1910, Odhner 1910 *a*
47.	E. africanus Stiles [=E. bursicola (Creplin) Looss]	Looss 1899, Stiles 1901
48.	E. oligacanthus Dietz [=E. euryporus Looss 1899 *nec* 1896]	Looss 1899, Dietz 1910

Genus *Echinochasmus* Dietz 1909 (*continued*)

*48 *a*. E. euryporus (Looss 1896 *nec* 1899)	Looss 1896
49. E. beleocephalus (v. Linstow)	Dietz 1910, Odhner 1910 *a*
50. E. coaxatus Dietz	Dietz 1909, 1910

Genus *Stephanoprora* Odhner 1902
[= *Mesorchis* Dietz + *Monilifer* Dietz]

51. S. pendula (Looss)	Looss 1899, Dietz 1910, Odhner 1910 *a*
52. S. denticulata (Rud.) [= E. pseudoechinatum Olsson = E. polycestus Dietz = ?E. spinulosum Rud.]	Dietz 1910, Odhner 1910 *a*
53. S. spinosa Odhner [= E. spinulosum Dietz *nec* Rud.]	Odhner 1910 *a*, Dietz 1910
*54. S. gilberti Ward	Gilbert 1905, Ward 1917

Genus *Heterechinostomum* Odhner 1910

55. H. mordax (Looss)	Looss 1899, Odhner 1910 *a*

Sub-family "*Parechinostominae*."

[= unclassified Echinostome genera.]

Genus *Parechinostomum* Dietz 1909

56. P. cinctum (Rud.)	Olsson 1876, Dietz 1910

Genus *Chaunocephalus* Dietz 1909

57. C. ferox (Zeder)	Mühling 1898, Dietz 1910

Genus *Pegosomum* Ràtz 1903

58. P. spiniferum Ràtz	Ràtz 1903, Dietz 1910, Odhner 1910 *a*
*58 *a*. P. saginatum (Ràtz)	Ràtz 1903, 1900 *b*

Genus *Hypoderaeum* Dietz 1909

59. H. conoideum (Bloch)	Kowalewski 1898 *b*, Dietz 1910

Genus *Paryphostomum* Dietz 1909

60. P. radiatum (Dujardin)	Dujardin 1845, Dietz 1910

Genus *Petasiger* Dietz 1909

61. P. exaeratus Dietz	Dietz 1909, 1910

Genus *Aporchis* Stossich 1905
[= *Macrechinostomum* Odhner 1910]

62. A. croaticus Stossich	Stossich 1905, Odhner 1910 *a*

Genus *Parorchis* Nicoll 1907

63. P. acanthus (Nicoll)	Nicoll 1907 *b*, Lebour and Elmhirst 1922
64. P. avitus Linton	Linton 1914
65. (P.) pittacius Braun	Braun 1901 *b*, 1902

Genus *Echinostephilla* Lebour 1909

66. E. virgula Lebour	Lebour 1909

Genus *Sodalis* Kowalewski 1902
[= *Scapanosoma* Lühe 1909]

67. S. spathulatus (Rud.)	Kowalewski 1902, Dietz 1910

Family OPISTHORCHIIDAE Lühe 1901 (*sens. strict.*).

Sub-family *Opisthorchiinae* Looss 1899.

Genus *Opisthorchis* R. Blanchard 1895

68. O. simulans Looss	Looss 1899, Barker 1911
69. O. geminus Looss	Looss 1899, Barker 1911
70. O. tenuicollis (Rud.)	Looss 1899, Barker 1911

Genus *Opisthorchis* R. Blanchard 1895 (*continued*)

71. O. entzi Ràtz	Ràtz 1900 *a*, Barker 1911
72. O. longissimus (v. Linstow)	Looss 1899, Barker 1911

Genus *Amphimerus* Barker 1911

73. A. speciosus (Stiles and Hassall)	Stiles and Hassall 1896, Barker 1911
74. A. lancea (Diesing)	Weski 1900, Barker 1911

Genus *Notaulus* Skrjabin 1913

75. N. asiaticus Skrjabin	Skrjabin 1913 *a*

Sub-family *Metorchiinae* Lühe 1909.

Genus *Metorchis* Looss 1899

76. M. crassiusculus (Rud.)	Kowalewski 1898 *a*, Looss 1899
77. M. xanthosomus (Creplin)	Braun 1902
„ *var.* compascuus (Kowalewski)	Kowalewski 1898 *a*
78. M. tener Kowalewski	Kowalewski 1898 *a*, 1903

Genus *Holometra* Looss 1899

79. H. exigua (Mühling)	Mühling 1898, Lühe 1908

Genus *Pachytrema* Looss 1907

80. P. calculus Looss	Looss 1907

Family Fasciolidae Railliet 1895.

Sub-family *Cathaemasiinae* Odhner 1911.

Genus *Cathaemasia* Looss 1899

81. C. hians (Rud.)	Mühling 1896, Looss 1899
82. C. fodicans Braun	Braun 1901 *b*, 1902

Family Clinostomidae Lühe 1901.

Genus *Clinostomum* Leidy 1856

83. C. complanatum (Rud.)	Braun 1900, Ciurea 1911
84. C. foliiforme Braun	Braun 1900
85. C. marginatum (Rud.)	Braun 1900, Osborn 1912
86. (C.) aequale Dujardin	Dujardin 1845, Looss 1899
87. (C.) heteroclitum Molin	Molin 1859 *a*, Looss 1899

Family Harmostomidae Odhner 1912.

Genus *Harmostomum* Braun 1899

88. H. caudale (Rud.)	Braun 1901 *b*, 1902
89. H. mesostomum (Rud.)	Wolffhügel 1900, Braun 1902
90. H. fuscatum (Rud.)	Braun 1902

Genus *Leucochloridium* Carus 1835
[= *Urogonimus* Monticelli 1888]

91. L. macrostomum (Rud.)	Stossich 1896, Braun 1902
92. L. turanicum (Solowiow)	Solowiow 1912

Family Schistosomidae Looss 1899.
[= *Bilharziidae* Odhner 1912.]

Genus *Bilharziella* Looss 1899

93. B. polonica (Kowalewski)	Kowalewski 1898 *a*, Braun 1902
94. B. pulverulenta Braun	Braun 1901 *b*, 1902

Genus *Gigantobilharzia* Odhner 1910

95. G. acotylea Odhner	Odhner 1910 *c*

Genus *Ornithobilharzia* Odhner 1912

96. O. intermedia Odhner	Odhner 1912

Family LEPODERMATIDAE Odhner 1910.

[= *Plagiorchidae* Lühe 1901 e.p.]

Genus *Lepoderma* Looss 1899
[= *Plagiorchis* Lühe 1899 e.p.]

97.	L. cirratum (Rud.)	Mühling 1896, Braun 1902
98.	L. elegans (Rud.)	Braun 1901 *b*, 1902
99.	L. notabile (Nicoll)	Nicoll 1909
100.	L. permixtum (Braun)	Braun 1901 *b*, 1902
101.	L. maculosum (Rud.)	Braun 1901 *b*, 1902
102.	L. triangulare (Diesing)	Braun 1901 *b*, 1902
103.	L. nanum (Rud.)	Braun 1901 *b*, 1902
104.	L. vitellatum (v. Linstow)	v. Linstow 1875, Braun 1902

Family DICROCOELIIDAE Odhner 1910.

Genus *Dicrocoelium* (Dujardin 1845) Looss

105.	D. petiolatum Railliet	Railliet 1900, Braun 1902
106.	D. clathratum (Deslongchamps)	Looss 1899, Braun 1902
107.	D. strigosum Looss	Looss 1899, Braun 1902
108.	D. skrjabinii Solowiow	Solowiow 1911, 1912
*109.	(D.) ventricosum Rud.	Kossack 1911
110.	(D.) spathula Dujardin	Dujardin 1845, Diesing 1850
111.	(D.) eurystomum v. Linstow	v. Linstow 1877, Stossich 1892

Genus *Lyperosomum* Looss 1899

112.	L. longicauda (Rud.) [= Dicrocoelium macrourum (Rud.)]	Mühling 1896, Braun 1902
113.	L. lobatum Railliet	Railliet 1900, Braun 1902
114.	L. salebrosum Braun	Braun 1901 *b*, 1902
115.	L. filiforme Skrjabin	Skrjabin 1913 *a*, 1914
116.	L. corrigia Braun	Braun 1901 *b*, 1902

Genus *Platynosomum* Looss 1907

117.	P. acuminatum Nicoll	Nicoll 1915

Genus *Athesmia* Looss 1899

118.	A. heterolecithodes (Braun)	Braun 1902, Goldberger and Crane 1911

Family CEPHALOGONIMIDAE Looss 1899.

Genus *Prosthogonimus* Lühe 1899

119.	P. cuneatus (Rud.)	Braun 1901 *a*, 1902
120.	P. ovatus (Rud.)	Braun 1901 *a*, 1902
121.	P. dogieli Skrjabin	Skrjabin 1915
122.	P. anatinus Markow	Markow 1903, Skrjabin 1916
123.	P. putschkowskii Skrjabin	Skrjabin 1912, 1916
124.	P. pellucidus (v. Linstow)	Braun 1901 *a*, 1902

Genus *Schistogonimus* Lühe 1909

125.	S. rarus (Braun)	Braun 1901 *a*, 1902, Lawrow 1908

Genus *Stomylotrema* Looss 1900

126.	S. pictum (Creplin)	Braun 1901 *b*, 1902
127.	S. perpastum Braun [= S. singularis Looss *nec* Molin]	Looss 1899, Braun 1902
128.	S. fastosum Braun	Braun 1901 *b*, 1902
128 *a*.	S. bijugum Braun	Braun 1901 *b*, 1902

Family Philophthalmidae Looss 1899.

Genus *Philophthalmus* Looss 1899

129. P. palpebrarum Looss	Looss 1899, Braun 1902
130. P. nocturnus Looss	Looss 1907 *b*
131. P. lucipetus (Rud.)	Looss 1899, Braun 1902

Genus *Pygorchis* Looss 1899

132. P. affixus Looss	Looss 1899, Braun 1902

Family Lecithodendriidae Odhner 1910.

Genus *Phaneropsolus* Looss 1899

133. P. sigmoideus Looss	Looss 1899, Braun 1902

Genus *Eumegacetes* Looss 1900

134. E. medioximus Braun	Braun 1901 *b*, 1902
135. E. emendatus Braun	Braun 1901 *b*, 1902
136. E. contributans Braun	Looss 1899, Braun 1902
[? = E. crassus v. Siebold]	

Family Heterophyidae Odhner 1914.

Sub-family *Cryptocotylinae* Lühe 1909.

Genus *Cryptocotyle* Lühe 1899
[= *Tocotrema* Looss 1899]

137. C. concava (Creplin)	Mühling 1898, Ransom 1920
138. C. lingua (Creplin)	Jägerskiöld 1898, Ransom 1920
139. C. jejuna (Nicoll)	Nicoll 1907 *a*, Ransom 1920
140. C. echinata (v. Linstow)	v. Linstow 1873

Genus *Scaphanocephalus* Jägerskiöld 1903

141. S. expansus (Creplin)	Jägerskiöld 1901, 1903

Genus *Apophallus* Lühe 1909

142. A. mühlingi (Jägerskiöld)	Jägerskiöld 1898, Ransom 1920

Genus *Ascocotyle* Looss 1899

143. A. minuta Looss	Looss 1899, Ransom 1920

Genus *Taphrogonimus* Cohn 1904

144. T. holostomoides (Mehlis)	Brandes 1892, Cohn 1904

Genus *Galactosomum* Looss 1899
[? = *Microlistrum* Braun 1901]

145. G. lacteum (Jägerskiöld)	Jägerskiöld 1896, 1908
146. (G.) semifuscum Olsson	Olsson 1876, Jägerskiöld 1908

Genus *Microlistrum* Braun 1901

147. M. cochlear (Diesing)	Braun 1902, Odhner 1910 *b*
148. M. cochleariforme (Rud.)	Odhner 1910 *b*, Pratt 1911

Sub-family *Microphallinae* Ward 1901.

Genus *Levinseniella* Stiles and Hassall 1901

149. L. brachysoma (Creplin)	Jägerskiöld 1907
150. L. pygmaea (Levinsen)	Jägerskiöld 1900 *b*, Odhner 1905
151. L. pellucida Jägerskiöld	Jägerskiöld 1907
152. L. propinqua Jägerskiöld	Jägerskiöld 1907
*153. L. howensis S. J. Johnston	S. J. Johnston 1917
154. (L.) macrophallos v. Linstow	Jägerskiöld 1907

Genus *Spelotrema* Jägerskiöld 1901

155. S. claviforme (Brandes)	Brandes 1889, Nicoll 1909
156. S. simile (Jägerskiöld)	Jägerskiöld 1900 *b*, Odhner 1905
157. S. excellens Nicoll	Nicoll 1907 *a*, 1909, Jägerskiöld 1908

Genus *Spelophallus* Jägerskiöld 1908

158.	S. primas Jägerskiöld	Jägerskiöld 1908

Genus *Maritrema* Nicoll 1907

159.	M. humile Nicoll	Nicoll 1907 *a*, 1909, Jägerskiöld 1908
160.	M. gratiosum Nicoll	Nicoll 1907 *a*, 1909, Jägerskiöld 1908
161.	M. lepidum Nicoll	Nicoll 1907 *a*, 1909, Jägerskiöld 1908
162.	M. linguilla Jägerskiöld	Jägerskiöld 1908
163.	M. subdolum Jägerskiöld	Jägerskiöld 1908

Sub-family *Gymnophallinae* Odhner 1905.

Genus *Gymnophallus* Odhner 1900

164.	G. somateriae (Levinsen)	Odhner 1900, 1905
165.	G. deliciosus (Olsson)	Olsson 1893, Odhner 1900
*166.	G. micropharyngeus (Lühe)	Lühe 1898, Odhner 1900
167.	G. choledochus Odhner	Odhner 1900, 1905
168.	G. bursicola Odhner	Odhner 1900, 1905
169.	G. dapsilis Nicoll	Nicoll 1907 *a*, 1909
170.	G. oidemiae Jameson and Nicoll	Jameson and Nicoll 1913
171.	G. affinis Jameson and Nicoll	Jameson and Nicoll 1913
172.	G. macroporus Jameson and Nicoll	Jameson and Nicoll 1913
173.	G. ovoplenus Jameson and Nicoll	Jameson and Nicoll 1913

Family TROGLOTREMIDAE Odhner 1914.

[= *Collyriclidae* Ward 1917.]

Genus *Collyriclum* Kossack 1911

174.	C. faba (Bremser)	Kossack 1911, Odhner 1914, Jegen 1917
175.	C. colei Ward	Cole 1911, Ward 1917

Genus *Renicola* Cohn 1904

176.	R. pinguis (Mehlis)	Cohn 1904, Odhner 1914

Unclassified Distomes.

177.	D. aculeatum Nitzsch	Giebel 1857, Braun 1901 *b*
178.	D. arcuatum Dujardin	Dujardin 1845, Wolffhügel 1900
179.	D. buteonis (Gmelin)	Zeder 1803, Diesing 1850
180.	D. capsulare Diesing	Wedl 1857, Diesing 1858, Solowiow 1912
181.	D. cladocalium Diesing	Diesing 1858, Braun 1893
182.	D. coelebs v. Linstow	v. Linstow 1875, Braun 1893
183.	D. collurionis Schrank	Zeder 1803, Stossich 1892
184.	D. constrictum Mehlis	Creplin 1846, Diesing 1850
185.	D. filum Dujardin	Dujardin 1845, Stossich 1892
186.	D. globocaudatum Creplin	Creplin 1849, Braun 1902
187.	D. intermedium Mehlis	Creplin 1846, Diesing 1850
188.	D. involutum Rud.	Rudolphi 1809, Braun 1901 *b*
189.	D. lineola Diesing	Diesing 1850, Braun 1901 *b*
190.	D. marculentum Braun	Braun 1901 *b*, 1902
191.	D. marginatum Molin	Molin 1858, 1861
192.	D. minutum Cobbold	Cobbold 1859, Mueller 1897
193.	D. nigrum v. Linstow	v. Linstow 1883, Stossich 1892
194.	D. polyoon v. Linstow	v. Linstow 1887, Braun 1902
195.	D. pyriforme Creplin	Creplin 1837, Diesing 1850
196.	D. vallei Stossich	Stossich 1896
197.	D. vexans Braun	Braun 1901 *b*, 1902

Super-family MONOSTOMATA Zeder 1800.

Family CYCLOCOELIDAE Kossack 1911.

Genus *Cyclocoelum* Brandes 1892

198.	C. brasilianum Stossich	Stossich 1902, Kossack 1911
199.	C. exile Stossich	Stossich 1902, Lühe 1909
200.	C. fasciatum (Stossich)	Stossich 1902, Lühe 1909
201.	C. microstomum (Creplin)	Creplin 1829, Kossack 1911
202.	C. mutabile (Zeder)	Stossich 1902, Kossack 1911
203.	C. orientale Skrjabin	Skrjabin 1913 *a*
204.	C. ovopunctatum Stossich	Stossich 1902, Kossack 1911
205.	C. problematicum Stossich	Stossich 1902, Kossack 1911
206.	C. vicarium (Arnsdorff)	Arnsdorff 1908, Kossack 1911

Genus *Haematotrephus* Stossich 1902

207.	H. fasciatus Stossich	Stossich 1902, Lühe 1909

Genus *Ophthalmophagus* Stossich 1902

208.	O. singularis Stossich	Stossich 1902, Kossack 1911

Genus *Hyptiasmus* Kossack 1911

209.	H. oculeus Kossack	Kossack 1911
210.	H. tumidus Kossack	Kossack 1911
211.	H. arcuatus (Brandes)	Stossich 1902, Kossack 1911
212.	H. laevigatus Kossack	Kossack 1911
213.	H. robustus (Stossich)	Stossich 1902, Lühe 1909
214.	(H.) adolphi Stossich	Stossich 1902, Kossack 1911
215.	(H.) ominosus Kossack	Kossack 1911

Genus *Typhlocoelum* Stossich 1903

216.	T. cucumerinum (Rud.) [= T. flavum (Mehlis)]	Stossich 1902, Kossack 1911

Family NOTOCOTYLIDAE Lühe 1909.

Genus *Notocotylus* Diesing 1839
[= *Notocotyle* Diesing]

217.	N. attenuatus (Rud.) [= N. triserialis Diesing]	Odhner 1905, Kossack 1911
218.	N. aegyptiacus (Odhner)	Odhner 1905
219.	N. diserialis Ssinizin	Ssinizin 1897
220.	N. gibbus (Mehlis)	Creplin 1846, Kossack 1911
221.	N. seineti Fuhrmann	Fuhrmann 1919

Genus *Catatropis* Odhner 1905

222.	C. verrucosa (Froelich)	Odhner 1905, Kossack 1911
*223.	C. liara Kossack	Kossack 1911
224.	C. charadrii Skrjabin	Skrjabin 1915 *a*

Genus *Paramonostomum* Lühe 1909

225.	P. alveatum (Mehlis)	Mühling 1898, Kossack 1911

? Family PRONOCEPHALIDAE Looss 1902.

Genus *Eucotyle* Cohn 1904

226.	E. nephritica (Creplin)	Cohn 1904, Odhner 1914

Unclassified Monostomes.

227.	M. angustum Schlotthauber	Schlotthauber 1860
228.	M. cornu (Zeder)	Rudolphi 1819, Brandes 1892
229.	M. crenulatum Rud.	Rudolphi 1809, Brandes 1892
230.	M. hyalinum Schlotthauber	Schlotthauber 1860
231.	M. ignotum Nicoll (*nom. nud.*)	Nicoll 1906

Unclassified Monostomes (continued)

232. M. macrostomum Rud.	Rudolphi 1809, Brandes 1892
233. M. macrourum Schlotthauber	Schlotthauber 1860
234. M. minutissimum Stossich	Stossich 1896, 1898 *b*
235. M. petasatum Deslongchamps	Deslongchamps 1824, Villot 1878
236. M. prismaticum Zeder	Zeder 1800, Looss 1902
237. M. vanelli Rud.	Rudolphi 1819, Kossack 1911

Super-family HOLOSTOMATA.

Genus *Strigea* Abildgaard 1790
[= *Holostomum* Nitzsch 1819]

238. S. strigis (Gmelin) [= H. variabile Nitzsch]	Molin 1861, Fischoeder 1903, Brandes 1890
239. S. agnavis Guberlet	Guberlet 1922
240. S. bursigera (Brandes)	Brandes 1888, 1890
241. S. cornu (Nitzsch)	Brandes 1890, Braun 1893
242. S. cornuta (Rud.)	Brandes 1888, Braun 1893
243. S. erratica (Rud. *nec* Brandes)	Diesing 1850, Lühe 1909
244. S. gracilis (Rud.)	v. Linstow 1877, Brandes 1890
245. S. longicollis (Rud.)	Brandes 1888, 1890
246. S. serpens (Nitzsch)	Brandes 1890, v. Linstow 1904
247. S. tarda (Steenstrup)	Lühe 1909
248. S. variegata (Creplin) [= Holostomum cucullus Thoss 1897]	Brandes 1888, Mühling 1898
249. Holostomum coniferum (Mehlis)	Creplin 1846
250. (H.) cornucopia Molin	Molin 1861, v. Linstow 1885
251. H. corones Diesing [= H. dubium Cobbold]	Brandes 1888, 1890
252. H. crenulatum Cobbold	Cobbold 1860, Brandes 1890
253. H. exiguum (Mehlis)	Creplin 1846
254. H. falconum Diesing	Brandes 1888, 1890
255. H. microstomum (Rud.)	Brandes 1890, Braun 1893
256. "H. ochreatum" Nitzsch	Giebel 1857
257. H. sphaerocephalum (Westrumb)	Brandes 1888, 1890
258. H. sphaerula (Rud.)	Dujardin 1845, Brandes 1890
259. H. squamosum Villot	Villot 1878, Brandes 1890
260. H. tenuicolle (Westrumb)	Diesing 1850, Brandes 1890

Genus *Hemistomum* Diesing 1850

261. H. attenuatum v. Linstow	v. Linstow 1906
262. H. auritum (Dujardin)	Dujardin 1845, Brandes 1890
263. H. confusum Krause	Krause 1914
264. H. denticulatum (Rud.)	Brandes 1890, Villot 1898
265. H. excavatum (Rud.)	Brandes 1890, Mühling 1898
266. H. gavium Guberlet	Guberlet 1922
267. H. pileatum (Rud.)	v. Linstow 1877 (*Holost. erraticum*), Brandes 1890
268. H. podomorphum (Nitzsch)	Brandes 1888, 1890
269. H. spathaceum (Rud.)	Villot 1898, Mühling 1898, Salzer 1907
270. H. spathula (Creplin)	Molin 1861, Brandes 1890

Genus *Cyathocotyle* Mühling 1896

271. C. prussica Mühling	Mühling 1896, Odhner 1913

Genus *Diplostomum* v. Nordmann 1832

272. D. auriflavum Molin	Molin 1861, Braun 1893
273. D. grande Diesing	Diesing 1855, Brandes 1890
274. D. macrostomum Jägerskiöld	Jägerskiöld 1900 *a*
275. D. spathulaeforme Brandes	Brandes 1890, Braun 1893

Super-family AMPHISTOMATA (Rud.) Nitzsch.
Family PARAMPHISTOMIDAE Fischoeder 1901.
Sub-family *Zygocotylinae* Stunkard 1916.

Genus *Zygocotyle* Stunkard 1916
276. Z. lunatum (Diesing) — Diesing 1836, Stunkard 1916

LIST OF BRITISH BIRDS WITH THEIR TREMATODE PARASITES[1].

I. PASSERIFORMES

i. *Corvidae*

1. *Corvus corax* L. Raven

Prosthogonimus cuneatus (Rud.)	Bursa Fabricii

2. *Corvus corone* L. Carrion crow

Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Lepoderma cirratum (Rud.)	Intestine
Lyperosomum longicauda (Rud.) [= D. macrourum Rud.]	Liver and gall-bladder
Lyperosomum sp. [= D. macrourum v. Linst.]	Bile ducts
Amphimerus speciosus (St. and H.)	Liver
Leucochloridium macrostomum (Rud.)	Intestine and Bursa Fabricii
Distomum arcuatum Duj.	Intestine
Holostomum sphaerula Duj.	Intestine
Holostomum corones Dies.	Intestine

3. *Corvus cornix* L. Hooded crow

Prosthogonimus ovatus (Rud.)	Intestine and Bursa Fabricii
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Philophthalmus palpebrarum Looss	Conjunctiva
Pygorchis affixus Looss	Cloaca
Lyperosomum longicauda (Rud.)	Gall-bladder
Dicrocoelium skrjabinii Solowiow	Gall-bladder
Echinostomum revolutum (Froelich)	Rectum
Distomum globocaudatum Creplin	Intestine
Distomum nigrum v. Linst.	Intestine
Holostomum sphaerula Duj.	Intestine

4. *Corvus monedula* L. Jackdaw

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Lepoderma cirratum (Rud.)	Intestine

5. *Corvus frugilegus* L. Rook

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Lepoderma cirratum (Rud.)	Intestine
Lyperosomum longicauda (Rud.)	Gall-bladder
Echinostomum mesotestius Solowiow	Intestine
Echinostomum sp. (Hausmann)	Intestine
Monostomum prismaticum Zeder	Abdominal cavity
Holostomum sphaerula Duj.	Intestine

6. *Pica pica* Linn. Magpie

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Lepoderma cirratum (Rud.)	Intestine

[1] Birds which are rare or only occasional visitors in the British area are marked *.

1. PASSERIFORMES

i. *Corvidae*

6. ***Pica pica*** **Linn.** ***(continued)***

? Lyperosomum longicauda (Rud.)	Liver
? Lyperosomum lobatum (Railliet)	Liver
? Amphimerus lancea (Diesing)	Liver
? Strigea strigis (Gmelin)	Intestine

7. *Garrulus glandarius* L. Jay.

Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Lyperosomum longicauda (Rud.)	Liver and gall-bladder
Dicrocoelium petiolatum Railliet	Liver
Harmostomum caudale (Rud.)	Rectum
Leucochloridium macrostomum (Rud.)	Intestine and Bursa Fabricii
Distomum arcuatum Duj.	Intestine
Distomum globocaudatum Creplin	Intestine
Collyriclum faba (Bremser)	In cysts under skin
Monostomum macrourum Schlotthauber (*nom. nud.*)	Intestine
Holostomum sphaerula Duj.	Intestine

8. *Nucifraga caryocatactes* Linn. Thick-billed Nutcracker

Lepoderma sp.	Rectum
[= Distomum caudale Willemoes-Suhm]	
Holostomum macrostomum Duj.	Rectum

ii. *Sturnidae*

9. *Sturnus vulgaris* Linn. Starling

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Lepoderma cirratum (Rud.)	Intestine
Lyperosomum longicauda (Rud.)	Liver
Collyriclum faba (Bremser)	In cysts under skin

iii. *Oriolidae*

10. *Oriolus oriolus* Linn. Golden oriole

[? = *Galbula grandis*]	
Eumegacetes medioximus Braun	Intestine

iv. *Fringillidae*

11. *Chloris chloris* Linn. Greenfinch

(Harmostomum) mesostomum Rud.	Intestine

12. *Coccothraustes coccothraustes* Linn. Hawfinch

(Harmostomum) mesostomum Rud.	Intestine

13. *Spinus spinus* (Linn.)

	Siskin
Collyriclum faba (Bremser)	In cysts under skin

14. *Passer domesticus* (Linn.). House sparrow

Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
[= Prymnoprion ovatus (Rud.) Looss]	
Lepoderma elegans (Rud.)	Intestine
Eumegacetes emendatus Braun	Intestine
[= Megacetes triangularis Looss]	
Phaneropsolus sigmoideus Looss	Intestine
Leucochloridium macrostomum (Rud.)	Cloaca
Collyriclum faba (Bremser)	In cysts under skin
Collyriclum colei Ward	In cysts under skin
Distomum filum Duj.	Intestine

15. *Passer montanus* Linn. Tree sparrow

Prosthogonimus ovatus (Rud.)	Bursa Fabricii

I. PASSERIFORMES

iv. *Fringillidae*

15. *Passer montanus* Linn. (*continued*)

Lepoderma cirratum (Rud.)	Intestine
Leucochloridium macrostomum (Rud.)	Intestine

16. *Fringilla coelebs* Linn. Chaffinch

Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
(Harmostomum) mesostomum Rud.	Intestine
Leucochloridium macrostomum (Rud.)	Intestine
Distomum coelebs v. Linstow (larva)	In cysts in intestinal wall

17. *Acanthis linaria* (Linn.). Mealy redpole

Leucochloridium macrostomum (Rud.)	Intestine

18. *Pyrrhula pyrrhula* (Linn.). Northern Bullfinch

Leucochloridium macrostomum (Rud.)	Intestine

19. *Emberiza intermedia* Linn. Yellow-Hammer

Distomum marculentum Braun	Intestine

20. *Emberiza cirlus* Linn. Cirl bunting

Collyriclum faba (Bremser)	In cysts under skin

v. *Motacillidae*

21. *Motacilla alba* Linn. White wagtail

Lepoderma elegans (Rud.)	Intestine
? Lepoderma cirratum (Rud.)	Intestine

22. *Motacilla boarula* Scopoli. Grey wagtail

Collyriclum faba (Bremser)	In cysts under skin

23. *Motacilla flava* Linn. Blue-headed wagtail

Lepoderma notabile (Nicoll)	Intestine
Spelotrema claviforme (Brandes)	Intestine

24. *Anthus petrosus* Montague. Rock pipit
[= *A. obscurus* Lath.]

Lepoderma notabile (Nicoll)	Intestine
Spelotrema claviforme (Brandes)	Intestine

vi. *Paridae*

25. *Parus major* Linn. Great titmouse

Lepoderma elegans (Rud.) [= D. erraticum v. Linstow]	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Collyriclum faba (Bremser)	In cysts under skin

26. *Parus palustris* Stejneger

Lepoderma elegans (Rud.)	Intestine

27. *Parus coeruleus* Linn. Blue titmouse

Lepoderma elegans (Rud.)	Intestine

vii. *Laniidae*

28. *Lanius excubitor* Linn. Great grey shrike

Leucochloridium macrostomum (Rud.)	Intestine

29. *Lanius minor* Gmelin. Lesser grey shrike

Prosthogonimus cuneatus (Rud.)	Bursa Fabricii

30. *Lanius collurio* Linn. Red-backed shrike

Distomum collurionis Zeder	Intestine
Holostomum sphaerula Duj.	Intestine

viii. *Sylviidae*

31. *Sylvia communis* Latham. White-throat

Leucochloridium macrostomum (Rud.)	Intestine

I. PASSERIFORMES

viii. *Sylviidae* (*continued*)

32. *Sylvia simplex* Latham. Garden warbler
[= *S. hortensis* Bechst.]

Collyriclum faba (Bremser)	In cysts under skin

33. *Sylvia nisoria* (Bechst.). Barred warbler

Leucochloridium macrostomum (Rud.)	Intestine

34. *Phylloscopus trochilus* (Linn.). Willow warbler

Collyriclum faba (Bremser)	In cysts under skin

35. *Phylloscopus sibilatrix* (Bechst.). Wood warbler

Collyriclum faba (Bremser)	In cysts under skin

ix. *Turdidae*

36. *Turdus viscivorus* Linn. Missel thrush

(Harmostomum) mesostomum (Rud.)	Intestine
? Prosthogonimus ovatus (Rud.)	Bursa Fabricii

37. *Turdus musicus* Linn. Song thrush

Lyperosomum longicauda (Rud.)	Liver

38. *Turdus iliacus* Linn. Redwing

(Harmostomum) mesostomum (Rud.)	Intestine

39. *Turdus merula* Linn. Blackbird

Lyperosomum longicauda (Rud.)	Liver and gall-bladder
(Harmostomum) mesostomum Rud.	Intestine
Distomum vexans Braun	Intestine

*40. *Monticola saxatilis* (Linn.). Rock thrush

Echinostomum nephrocephalum (Dies.)	Intestine

41. *Phoenicurus phoenicurus* (Linn.). Redstart

"Monostomum crenulatum" Rud.	Intestine

42. *Luscinia megarhyncha* Brehm. Nightingale

Leucochloridium macrostomum (Rud.)	Intestine
(Dicrocoelium) ventricosum Rud.	Liver

*43. *Luscinia luscinia* (Linn.). Sprosser

Lyperosomum longicauda	Liver

44. *Oenanthe oenanthe* (Linn.). Wheatear

Collyriclum faba (Bremser)	In cysts under skin

45. *Accentor modularis* (Linn.). Hedge sparrow

(Dicrocoelium) spatula Duj.	Intestine

x. *Hirundinidae*

46. *Hirundo rustica* Linn. Swallow

Lepoderma permixtum (Braun)	Intestine
Lepoderma maculosum (Rud.)	Intestine
Prosthogonimus dogieli Skrjabin	Bursa Fabricii
Eumegacetes contribulans (Braun)	Cloaca

47. *Delichon urbica* (Linn.). Marten

Lepoderma maculosum (Rud.)	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Eumegacetes contribulans (Braun)	Cloaca and intestine

48. *Riparia riparia* (Linn.). Sand-marten

Lepoderma maculosum (Rud.)	Intestine

II. CORACIIFORMES

A. *Cypseli*

i. *Cypselidae*

49. *Micropus apus* (Linn.). Swift

Lepoderma maculosum (Rud.)	Intestine
Dicrocoelium clathratum (Deslongchamps) [= Distomum refertum Mühling]	Gall-bladder

50. *Micropus melba* (Linn.). Alpine swift

Lyperosomum salebrosum Braun	Intestine

B. *Caprimulgi*

i. *Caprimulgidae*

51. *Caprimulgus europaeus* Linn. Nightjar

Lepoderma maculosum (Rud.)	Intestine
Phaneropsolus sigmoideus Looss	Intestine
Eumegacetes emendatus Braun	Intestine

C. *Meropes*

i. *Meropidae*

52. *Merops apiaster* Linn. Bee-eater

Lepoderma triangulare (Diesing)	Intestine
Eumegacetes emendatus Braun	Intestine
Dicrocoelium strigosum Looss	Bile ducts

D. *Upupae*

i. *Upupidae*

53. *Upupa epops* Linn. Hoopoe

Distomum involutum Rud.	Intestine

E. *Halcyones*

i. *Alcedinidae*

54. *Alcedo ispida* Linn. Kingfisher

Hemistomum denticulatum Dies.	Intestine

F. *Coraciae*

i. *Coraciidae*

55. *Coracias garrulus* Linn. Roller

Leucochloridium macrostomum (Rud.)	Intestine
Echinostomum revolutum (Froelich)	Rectum

III. STRIGIFORMES

i. *Flammeidae*

56. *Flammea flammea* (Linn.). Barn owl

Echinostomum stridulae (Reich)	Intestine
(Clinostomum) aequale Duj.	Intestine
Strigea strigis (Gmelin)	Intestine
(Holostomum) cornucopiae Molin	Intestine
Hemistomum auritum (Duj.)	Intestine

ii. *Strigidae*

57. *Asio otus* (Linn.). Long-eared owl

Strigea strigis (Gmelin)	Intestine
(Holostomum) cornucopiae Molin	Intestine
Hemistomum spathula (Creplin)	Intestine
Diplostomum spathulaeforme Brandes	Intestine

58. *Asio accipitrinus* (Pallas). Short-eared owl

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Strigea strigis (Gmelin)	Intestine
Hemistomum spathula (Creplin)	Intestine

III. STRIGIFORMES
ii. *Strigidae* (*continued*)

59. *Strix aluco* Linn. Tawny owl	
Echinostomum stridulae (Reich)	Intestine
Strigea strigis (Gmelin)	Intestine
Hemistomum spathula (Creplin)	Intestine
60. *Nyctea nyctea* (Linn.). Snowy owl	
Metorchis crassiusculus (Rud.)	Gall-bladder
Strigea strigis (Gmel.)	Intestine
Diplostomum grande Diesing	Intestine
61. *Nyctala funerea* (Linn.). Tengmalm's owl	
Strigea strigis (Gmel.)	Intestine
62. *Otus scops* (Linn.). Scops owl	
Lepoderma elegans (Rud.)	Intestine
63. *Bubo bubo* (Linn.). Eagle owl	
Distomum aculeatum Nitzsch	Intestine
Strigea strigis (Gmel.)	Intestine
Hemistomum spathula (Creplin)	Intestine
64. *Carine noctua* (Scop.). Little owl	
Philophthalmus nocturnus Looss	Conjunctiva

IV. ACCIPITRIFORMES
A. *Accipitres*
i. *Falconidae*

65. *Circus aeruginosus* (Linn.). Marsh harrier	
[? = *C. rufus* Gray]	
Opisthorchis simulans Looss	Liver
Opisthorchis geminus Looss	Liver
Metorchis crassiusculus (Rud.)	Liver and gall-bladder
Pygorchis affixus Looss	Cloaca
Strigea strigis (Gmelin)	Intestine
Hemistomum spathula (Creplin)	Intestine
(In *Circus rufus*)	
Holometra exigua Mühling	Liver
Distomum lineola Diesing	Liver
Holostomum tenuicolle Diesing	Intestine
"Holostomum falconum" Diesing	Intestine
66. *Circus cyaneus* (Linn.). Hen harrier	
? Echinochasmus africanus Stiles	Bursa Fabricii
Strigea strigis (Gmelin)	Intestine
Hemistomum spathula (Creplin)	Intestine
67. *Circus pygargus* (Linn.). Montagu's harrier	
[= *C. cineraceus* Montagu]	
Notaulus asiaticus Skrjabin	Liver?
Lyperosomum filiforme Skrjabin	Bile duct
Strigea strigis (Gmelin)	Intestine
Hemistomum podomorphum (Nitzsch)	Intestine
68. *Buteo buteo* (Linn.). Buzzard	
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Echinoparyphium agnatum Dietz	Intestine
[= Echinostomum echinatum Mühling]	
Metorchis crassiusculus (Rud.)	Gall-bladder
Distomum buteonis (Gmelin)	Intestine
Strigea strigis (Gmelin)	Intestine

IV. ACCIPITRIFORMES

A. *Accipitres*

i. *Falconidae*

68. *Buteo buteo* Linn. (*continued*)

Hemistomum spathula (Creplin)	Intestine
Hemistomum pileatum Brandes	Intestine
Hemistomum attenuatum v. Linstow	Intestine
Diplostomum spathulaeforme Brandes	Intestine

69. *Buteo lagopus* (Brünnich). Rough-legged buzzard

Metorchis crassiusculus (Rud.)	Gall-bladder
Strigea strigis (Gmelin)	Intestine
Hemistomum spathula (Creplin)	Intestine

70. *Aquila chrysaëtus* (Linn.). Golden eagle

Metorchis crassiusculus (Rud.)	Gall-bladder
Hemistomum spathula (Creplin)	Intestine

71. *Haliaëtus albicilla* (Linn.). White-tailed eagle

Metorchis crassiusculus (Rud.)	Gall-bladder
Hemistomum spathula (Creplin)	Intestine
Strigea strigis (Gmelin)	Intestine
? Strigea variegata (Creplin)	Intestine

72. *Astur palumbarius* (Linn.). Goshawk

Hemistomum spathula (Creplin)	Intestine
"Holostomum falconum" Diesing	Intestine

73. *Accipiter nisus* (Linn.). Sparrow hawk

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Hemistomum spathula (Creplin)	Intestine
Strigea strigis (Gmelin)	Intestine
Strigea cornu (Nitzsch)	Intestine
"Holostomum falconum" Diesing	Intestine
Diplostomum spathulaeforme Brandes	Intestine

74. *Milvus milvus* (Linn.). Kite

Echinostomum echinocephalum (Rud.)	Intestine
Hemistomum spathula (Creplin)	Intestine

*75. *Milvus migrans* (Boddaert). Black kite

Echinochasmus euryporus (Looss)	Intestine
Hemistomum spathula (Creplin)	Intestine

76. *Pernis apivorus* (Linn.). Honey buzzard

? Echinostomum revolutum (Froelich)	Intestine
Echinostomum liliputanum Looss	Intestine
Opisthorchis simulans Looss	Bile duct

77. *Falco peregrinus* Tunstall. Peregrine falcon

Hemistomum spathula (Creplin)	Intestine
Strigea strigis (Gmelin)	Intestine

78. *Falco subbuteo* Linn. Hobby

Lepoderma elegans (Rud.)	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Distomum vallei Stossich	Intestine
Hemistomum spathula (Creplin)	Intestine
Strigea strigis (Gmelin)	Intestine

79. *Falco aesalon* Tunstall. Merlin

Strigea strigis (Gmelin)	Intestine

80. *Falco vespertinus* Linn. Red-footed falcon

Strigea strigis (Gmelin)	Intestine

IV. ACCIPITRIFORMES

A. *Accipitres*

i. *Falconidae (continued)*

81. *Falco tinnunculus* Linn. Kestrel

Echinochasmus africanus (Stiles)	Cloaca
Echinostomum spec. (Dietz)	Intestine
Pygorchis affixus Looss	Cloaca
Platynosomum acuminatum Nicoll	Liver
Strigea strigis (Gmelin)	Intestine

B. *Pandiones*

82. *Pandion haliaëtus* (Linn.). Osprey

Echinostomum spec. (Dietz)	Intestine
Scaphanocephalus expansus (Creplin)	Intestine
Cryptocotyle echinatum (v. Linstow)	Intestine
Hemistomum podomorphum (Nitzsch)	Intestine
Strigea strigis (Gmelin)	Intestine
Strigea serpens (Rud.)	Intestine
"Holostomum ochreatum" Nitzsch	Intestine

V. PELECANIFORMES

i. *Phalacrocoridae*

83. *Phalacrocorax carbo* (Linn.). Cormorant

Paryphostomum radiatum (Duj.)	Intestine
Petasiger exaeratus Dietz	Intestine
Echinostomum exechinatum Solowiow	Intestine
Galactosomum lacteum Jägerskiöld	Intestine
Hemistomum confusum Krause	Intestine
Strigea variegata (Creplin)	Intestine

84. *Phalacrocorax graculus* (Linn.). Shag

Paryphostomum radiatum (Duj.)	Intestine
Aporchis croaticus (Stossich)	Intestine
Echinostomum spec. (? spinulosum Rud.)	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca

ii. *Sulidae*

85. *Sula bassana* (Linn.). Gannet

(Galactosomum) semifuscum Olsson	Intestine
Hemistomum spathaceum (Rud.)	Intestine
? Hemistomum pileatum (Rud.)	Intestine

VI. ANSERIFORMES

i. *Anatidae*

86. *Anser anser* Linn. Grey lag goose

Echinostomum revolutum (Froelich)	Rectum
Hypoderaeum conoideum (Bloch)	Intestine
Prosthogonimus spec. (? ovatus Rud.)	Bursa Fabricii
Paramonostomum alveatum (Mehlis)	Coeca and intestine
Notocotylus attenuatus Rud.	Coeca and rectum
Catatropis verrucosa (Froelich)	Coeca and rectum
Hyptiasmus tumidus Kossack	Infra-orbital sinus and antrum
Monostomum arcuatum Brandes	Infra-orbital sinus
? Monostomum mutabile Zeder	Infra-orbital sinus

87. *Anser fabalis* Latham. Bean goose
[= *A. segetum* Gmelin]

Notocotylus attenuatus (Rud.)	Coeca and rectum
? Catatropis verrucosa (Froelich)	Coeca and rectum

VI. ANSERIFORMES

i. *Anatidae* (*continued*)

88. *Anser albifrons* (Scop.). White-fronted goose

Hypoderaeum conoideum (Bloch)	Intestine
Notocotylus attenuatus (Rud.)	Coeca and rectum
Catatropis verrucosa (Froel.)	Coeca and rectum
? Strigea gracilis (Rud.)	Intestine

89. *Branta bernicla* (Linn.). Brent goose

Notocotylus attenuatus (Rud.)	Intestine
Paramonostomum alveatum (Mehlis)	Intestine

90. *Branta leucopsis* (Bechstein). Barnacle goose

? Notocotylus attenuatus (Rud.)	Intestine and coeca
Catatropis verrucosa (Froelich)	Coeca and rectum

91. *Cygnus cygnus* (Linn.). Whooper swan

Echinostomum revolutum (Froelich)	Rectum
Echinostomum paraulum Dietz	Intestine
Echinostomum sp. (Dietz)	Intestine
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Notocotylus attenu[illegible]s Rud.	Coeca and rectum
Catatropis verrucosa (Froelich)	Coeca and rectum
Paramonostomum alveatum (Mehlis)	Coeca and rectum
? Strigea tarda (Steenstrup)	Intestine
"Holostomum exiguum" Mehlis	Intestine

92. *Cygnus olor* (Gmelin). Mute swan

Echinostomum revolutum (Froelich)	Rectum
Echinostomum sp. (Dietz)	Intestine
? Sphaeridiotrema globulus (Rud.)	Intestine
? Catatropis verrucosa (Froelich)	Coeca
Paramonostomum alveatum (Mehlis)	Rectum

93. *Tadorna tadorna* (Linn.). Common sheld duck

Gymnophallus choledochus Odhner	Gall-bladder
Psilochasmus oxyurus (Creplin)	Intestine
Echinostomum revolutum (Froelich)	Rectum
Hypoderaeum conoideum (Bloch)	Intestine
Notocotylus attenuatus (Rud.)	Coeca and rectum
Catatropis verrucosa (Froelich)	Coeca and rectum
? Strigea tarda (Steenstrup)	Intestine
Strigea erratica (Rud.)	Intestine

94. *Anas boschas* (Linn.). Mallard

Echinostomum revolutum (Froelich)	Rectum
Echinostomum paraulum Dietz	Intestine
Hypoderaeum conoideum (Bloch)	Rectum
Schistogonimus rarus (Braun)	Bursa Fabricii
Dicrocoelium spec.	Bile ducts
Metorchis crassiusculus (Rud.)	Gall-bladder
Opisthorchis simulans Looss	Bile ducts
Opisthorchis geminus (Looss)	Liver
Levinseniella pellucida Jägerskiöld	Coeca
Bilharziella polonica (Kowalewski)	Blood vessels
Notocotylus attenuatus (Rud.)	Coeca and rectum
? Catatropis verrucosa (Froelich)	Coeca
Monostomum minutissimum Stossich	Intestine
? Strigea tarda (Steenstrup)	Intestine
? Strigea gracilis (Rud.)	Intestine

VI. ANSERIFORMES

i. *Anatidae*

94. *Anas boschas* Linn. (*continued*)

? Strigea erratica (Rud.)	Intestine
? Strigea variegata (Creplin)	Intestine and Bursa Fabricii
Zygocotyle cenatosa Stunkard	Intestine

94 *a*. *Anas boschas dom.* Duck

Echinostomum revolutum (Froelich)	Rectum
Hypoderaeum conoideum (Bloch)	Rectum
Echinoparyphium recurvatum (v. Linst.)	Intestine
Metorchis xanthosomus (Creplin)	Gall-bladder
Metorchis crassiusculus (Rud.)	Bile ducts
Opisthorchis simulans Looss	Liver
Prosthogonimus anatinus Markow	Bursa Fabricii
Notocotylus attenuatus (Rud.)	Coeca and rectum
Notocotylus aegyptiacus Odhner	Coeca
Monostomum minutissimum Stossich	Intestine
Strigea tarda (Steenstrup)	Intestine
Holostomum sphaerocephalum (Westrumb)	Intestine

95. *Anas strepera* Linn. Gadwell

Echinostomum sp. (Dietz)	Intestine
Strigea sp. (Skrjabin)	Intestine

96. *Querquedula querquedula* (Linn.). Garganey

Echinostomum revolutum (Froelich)	Rectum
Hypoderaeum conoideum (Bloch)	Intestine
Metorchis xanthosomus *var.* compascuus Kowalewski	Gall-bladder
Bilharziella pulverulenta Braun	Blood vessels
Bilharziella polonica Kowalewski	Blood vessels
? Notocotylus attenuatus (Rud.)	Coeca and rectum
Notocotylus seineti Fuhrmann	Intestine
Catatropis verrucosa (Froelich)	Coeca and rectum

97. *Querquedula crecca* (Linn.). Common teal

Echinostomum revolutum (Froel.)	Intestine
Hypoderaeum conoideum (Bloch)	Intestine
Bilharziella polonica (Kowalewski)	Blood vessels
Distomum marginatum Molin	Intestine
Catatropis verrucosa (Froelich)	Coeca
Notocotylus attenuatus (Rud.)	Coeca
Strigea erratica (Rud.)	Rectum

98. *Mareca penelope* (Linn.). Wigeon

Echinostomum revolutum (Froelich)	Rectum
Echinostomum paraulum Dietz	Intestine
Opisthorchis simulans Looss	Bile ducts
Catatropis verrucosa (Froelich)	Coeca and rectum
Notocotylus attenuatus (Rud.)	Coeca and rectum
Paramonostomum alveatum (Mehlis)	Coeca and rectum

99. *Spatula clypeata* (Linn.). Shoveller

? Echinostomum revolutum (Froelich)	Intestine
Echinostomum baculus (Dies.)	Intestine
Hypoderaeum conoideum (Bloch)	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Schistogonimus rarus (Braun)	Bursa Fabricii
Notocotylus attenuatus (Rud.)	Coeca and rectum
? Catatropis verrucosa (Froelich)	Coeca and rectum

VI. ANSERIFORMES

i. *Anatidae* (*continued*)

100. *Dafila acuta* (Linn.). Pintail

Sphaeridiotrema globulus (Rud.)	Intestine
Bilharziella polonica Kowalewski	Blood vessels
Notocotylus attenuatus (Rud.)	Coeca and rectum

101. *Netta rufina* (Pallas). Red-crested pochard

Notocotylus attenuatus (Rud.)	Intestine

102. *Nyroca nyroca* (Güldenstädt). White-eyed pochard

Echinostomum sp. (? revolutum) Dietz	Intestine
Psilotrema spiculigerum (Mühling)	Intestine
Psilotrema simillimum (Mühling)	Intestine
Psilochasmus longicirratus Skrjabin	Intestine
? Strigea tarda (Steenstrup)	Intestine
? Strigea variegata (Creplin)	Intestine

103. *Nyroca ferina* (Linn.). Pochard

Echinostomum revolutum (Froelich)	Intestine
Hypoderaeum conoideum (Bloch)	Intestine
Prosthogonimus sp. (? cuneatus)	Bursa Fabricii
Strigea erratica (Rud.)	Intestine
Notocotylus attenuatus (Rud.)	Coeca and rectum
? Catatropis verrucosa (Froelich)	Coeca and rectum

104. *Nyroca marila* (Linn.). Scaup

Echinostomum revolutum (Froelich)	Intestine
Echinostomum baculus (Diesing)	Intestine
Hypoderaeum conoideum (Bloch)	Intestine
Stephanoprora spinosa Odhner	Intestine
(Echinoparyphium) recurvatum v. Linst.	Intestine
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Cryptocotyle concava (Creplin)	Intestine and coeca
Psilochasmus oxyurus (Creplin)	Intestine
Sphaeridiotrema globulus (Rud.)	Intestine
Notocotylus attenuatus (Rud.)	Coeca and rectum
? Catatropis verrucosa (Froelich)	Coeca and rectum
Paramonostomum alveatum (Mehlis)	Coeca and rectum
Typhlocoelum cucumerinum (Rud.)	Nasal cavity, trachea and bronchi
? Strigea tarda (Steenstrup)	Intestine
? Strigea erratica (Rud.)	Intestine

105. *Nyroca fuligula* (Linn.). Tufted duck

? Echinostomum revolutum (Froelich)	Intestine
Echinostomum baculus (Dies.)	Intestine
(Echinoparyphium) recurvatum v. Linst.	Intestine
Psilochasmus oxyurus (Creplin)	Intestine
Sphaeridiotrema globulus (Rud.)	Intestine
Opisthorchis simulans Looss	Liver
Levinseniella pellucida (Jägerskiöld)	Coeca
Cryptocotyle concava (Creplin)	Intestine
Bilharziella polonica (Kowalewski)	Veins
Hyptiasmus laevigatus Kossack	Nasal and infra-orbital sinuses
Hyptiasmus robustus (Stoss.)	Nasal cavity
Typhlocoelum cucumerinum (Rud.)	Nasal cavity, trachea and bronchi
Catatropis verrucosa (Froelich)	Coeca and rectum
Notocotylus attenuatus	Coeca and rectum

106. *Glaucion clangula* (Linn.). Golden eye

? Echinostomum revolutum (Froelich)	Intestine

VI. ANSERIFORMES

i. *Anatidae*

106. *Glaucion clangula* (Linn.) (*continued*)

Stephanoprora spinosa Odhner	Intestine
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Psilochasmus oxyurus (Creplin)	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca
? Levinseniella brachysoma (Creplin)	Intestine
(Dicrocoelium) eurystomum (v. Linstow)	Intestine
Catatropis verrucosa (Froelich)	Coeca
? Cyclocoelum mutabile (Zeder)	Infra-orbital sinus
Hyptiasmus arcuatus (Stoss.)	Infra-orbital sinus
Strigea tarda (Steenstrup)	Intestine
Strigea erratica (Rud.)	Intestine

107. *Clangula hyemalis* (Linn.). Long-tailed duck [= *Harelda glacialis* (Linn.)]

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Psilochasmus oxyurus (Creplin)	Intestine
Psilostomum brevicolle (Creplin) [= P. platyurum Mühling]	Intestine
Sphaeridiotrema globulus (Rud.)	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca
? Levinseniella brachysoma (Creplin)	Coeca
Catatropis verrucosa (Froelich)	Coeca and rectum
Notocotylus attenuatus (Rud.)	Coeca and intestine
Paramonostomum alveatum (Mehlis)	Coeca and rectum
Hyptiasmus laevigatus Kossack	Nasal and infra-orbital sinuses
Typhlocoelum cucumerinum (Rud.)	Nasal cavity, trachea and bronchi
Cyathocotyle prussica Mühling	Intestine
? Strigea tarda (Steenstrup)	Intestine
Strigea variegata (Creplin)	Intestine
Strigea erratica (Rud.)	Intestine

108. *Somateria mollissima* (Linn.). Eider duck

Gymnophallus somateriae (Levinsen)	Intestine
Gymnophallus bursicola Odhner	Bursa Fabricii
Gymnophallus choledochus Odhner	Gall-bladder
Spelotrema pygmaeum (Levinsen)	Intestine
Spelophallus primas Jägerskiöld	Intestine
Distomum constrictum Mehlis	Intestine
Paramonostomum alveatum (Mehlis)	Intestine
Catatropis verrucosa (Froelich)	Coeca and intestine
Notocotylus attenuatus (Rud.)	Coeca and intestine
Typhlocoelum cucumerinum (Rud.)	Oesophagus and air sacs
Hyptiasmus laevigatus Kossack	Nasal and infra-orbital sinuses
? Strigea tarda Steenstrup	Intestine
? Strigea erratica (Rud.)	Intestine

109. *Somateria spectabilis* (Linn.). King eider

Gymnophallus somateriae (Levinsen)	Coeca
Gymnophallus choledochus Odhner	Gall-bladder
Spelotrema pygmaeum (Levinsen)	Intestine

110. *Oedemia nigra* (Linn.). Common scoter

Echinostomum revolutum (Froelich)	Rectum
Psilochasmus oxyurus (Creplin)	Intestine
Psilostomum brevicolle (Creplin)	Intestine
Metorchis xanthosomus (Creplin)	Gall-bladder

VI. ANSERIFORMES

i. *Anatidae*

110. *Oedemia nigra* Linn. (*continued*)

Gymnophallus somateriae (Levinsen)	Intestine and coeca
Gymnophallus dapsilis Nicoll	Bursa Fabricii and intestine
Gymnophallus bursicola Odhner	Bursa Fabricii
Gymnophallus oidemiae Jameson and Nicoll	Intestine
Gymnophallus affinis Jameson and Nicoll	Intestine
Gymnophallus ovoplenus Jameson and Nicoll	Intestine
Gymnophallus macroporus Jameson and Nicoll	Intestine
Spelotrema pygmaeum (Levinsen)	Intestine
Levinseniella brachysoma (Creplin)	Intestine
Cryptocotyle concava (Creplin)	Intestine
Distomum constrictum Mehlis	Intestine
Catatropis verrucosa (Froelich)	Bursa Fabricii
Paramonostomum alveatum (Mehlis)	Intestine
Cyclocoelum mutabile (Zeder)	Nasal fossae
Hyptiasmus laevigatus Kossack	Nasal and infra-orbital sinuses
? Strigea tarda (Steenstrup)	Intestine
? Strigea gracilis (Rud.)	Intestine
Holostomum crenulatum Cobbold	Intestine

111. *Oidemia fusca* (Linn.). Velvet scoter

Echinostomum baculus (Diesing)	Intestine
Gymnophallus dapsilis Nicoll	Bursa Fabricii
Spelotrema pygmaeum (Levinsen)	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca
? Psilostomum brevicolle (Creplin) [= Distomum pyriforme Creplin]	Intestine
Orchipedum tracheicola Braun	Trachea
Notocotylus attenuatus (Rud.)	Coeca and rectum
Catatropis verrucosa (Froelich)	Coeca and rectum
Paramonostomum alveatum (Mehlis)	Coeca and rectum
Typhlocoelum cucumerinum (Rud.)	Air sacs and trachea
Hyptiasmus laevigatus Kossack	Nasal and infra-orbital sinuses
? Strigea tarda Steenstrup	Intestine
? Strigea erratica (Rud.)	Intestine
? Strigea gracilis (Rud.)	Intestine
Cyathocotyle prussica Mühling	Intestine

112. *Mergus merganser* Linn. Goosander

Hypoderaeum conoideum (Bloch)	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca
Sphaeridiotrema globulus (Rud.)	Intestine
Metorchis tener Kowalewski	Liver
Catatropis verrucosa (Froelich)	Coeca
Notocotylus attenuatus (Rud.)	Coeca and rectum
Strigea gracilis (Rud.)	Intestine
Strigea erratica (Rud.)	Intestine
"Holostomum exiguum" Mehlis	Intestine
? Hemistomum pileatum Brandes	Intestine

113. *Mergus serrator* Linn. Red-breasted merganser

Heterechinostomum sp. (Odhner)	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca
Sphaeridiotrema globulus (Rud.)	Intestine
Catatropis verrucosa (Froelich)	Coeca and rectum
Typhlocoelum cucumerinum (Rud.)	Air passages
Strigea gracilis (Rud.)	Intestine

VI. ANSERIFORMES

i. *Anatidae* (*continued*)

114. "Holostomum exiguum" Mehlis — Intestine

Mergellus albellus (Linn.). Smew

Echinoparyphium baculus (v. Linstow)	Intestine
Bilharziella polonica (Kowalewski)	Veins
Typhlocoelum cucumerinum (Rud.)	Bronchi, nares and infra-orbital sinuses
Hyptiasmus arcuatus (Stossich)	Bronchi
Strigea gracilis (Rud.)	Intestine
Strigea erratica (Rud.)	Intestine

VII. PHOENICOPTERIFORMES

Phoenicopteridae

*115. *Phoenicopterus antiquorum* Temminck. Flamingo [= *P. roseus* Pallas]

Acanthoparyphium phoenicopteri (Lühe)	Intestine
Echinoparyphium elegans (Looss)	Intestine
Gymnophallus micropharyngeus (Lühe)	Gall-bladder
Catatropis liara Kossack	Coeca

VIII. ARDEIFORMES

i. *Ardeae*

Ardeidae

116. *Ardea cinerea* Linn. Heron

Echinochasmus bursicola (Creplin)	Bursa Fabricii
Echinochasmus oligacanthus Dietz	Intestine and coeca
Echinochasmus beleocephalus (v. Linstow)	Intestine
Clinostomum complanatum (Rud.)	Mouth and oesophagus
Clinostomum heterostomum (Rud.)	Mouth and oesophagus
Cathaemasia hians (Rud.)	Oesophagus
Ascocotyle minuta Looss	Intestine
Levinseniella brachysoma (Creplin)	Intestine and coeca
Bilharziella polonica Kowalewski	Veins
Distomum capsulare Diesing	In cysts under skin
Cyclocoelum adolphi (Stossich)	Frontal sinus
Monostomum cornu (Zeder)	Intestine
Strigea cornu (Rud.)	Intestine
? Strigea strigis (Gmelin)	Intestine
"Holostomum lyratum" Schlotth.	Intestine

117. *Ardea purpurea* Linn. Purple heron

Echinochasmus bursicola (Creplin)	Bursa Fabricii
Clinostomum marginatum (Rud.)	Mouth and oesophagus
Clinostomum foliiforme Braun	Mouth and oesophagus
Opisthorchis entzi v. Ràtz	Gall-bladder
Distomum capsulare Diesing	In cysts in oesophageal wall
Strigea cornu (Rud.)	Intestine

*118. *Egretta alba* (Linn.). Great white heron

Pegosomum saginatum (v. Ràtz)	Bile duct
Clinostomum marginatum (Rud.)	Mouth
Amphimerus speciosus Stiles and Hassall	Bile duct
Strigea longicollis (Rud.)	Intestine
? Strigea cornu (Rud.)	Intestine

*119. *Egretta garzetta* (Linn.). Little egret

Nephrostomum ramosum (Sonsino)	Intestine
Strigea cornu (Rud.)	Intestine

VIII. ARDEIFORMES

i. *Ardeae*

Ardeidae (*continued*)

*120. *Ardeola ibis* Linn. Buff-backed heron
[= *Bubulcus lucidus* Rafines.]

Nephrostomum ramosum (Sonsino)	Intestine
Echinochasmus bursicola (Creplin)	Bursa Fabricii

121. *Ixorhynchus minutus* (Linn.). Little bittern

Scaponosoma spathulatum (Rud.)	Intestine
Distomum cladocalium Diesing	Bile ducts

122. *Nycticorax nycticorax* (Linn.). Night heron
[= *N. griseus* L.]

? Echinostomum revolutum (Froelich)	Intestine
Cathaemasia hians (Rud.)	Oesophagus
? Clinostomum heterostomum (Rud.)	Oesophagus
? Clinostomum marginatum (Rud.)	Mouth
Cryptocotyle lingua (Creplin)	Intestine
Distomum capsulare Diesing	In cysts in pectoral muscles
Monostomum cornu Rud.	Intestine
Diplostomum auriflavum Molin	Intestine
Hemistomum excavatum (Rud.)	Intestine
Strigea cornu (Rud.)	Intestine

123. *Botaurus stellaris* (Linn.). Bittern

Chaunocephalus ferox (Zed.)	Intestine
Pegosomum spiniferum Rätz	Bile ducts
Echinochasmus bursicola (Creplin)	Bursa Fabricii
Opisthorchis longissimus (v. Linstow)	Liver and bile ducts
Distomum capsulare Diesing	In cysts in muscles
? Hemistomum spathula (Creplin)	Intestine
Strigea longicollis (Rud.)	Intestine
? Strigea cornu (Rud.)	Intestine
"Holostomum patagiatum" (Mehlis)	Intestine

ii. *Ciconiae*

Ciconidae

124. *Ciconia ciconia* (Linn.). White stork
[= *C. alba* Bechst.]

Chaunocephalus ferox (Zed.)	Intestine
Echinochasmus coaxatus Dietz	Intestine
? Echinostomum revolutum (Froelich)	Intestine
Cathaemasia hians (Rud.)	Oesophagus
Stomylotrema pictum (Creplin)	Cloaca
Hemistomum excavatum (Rud.)	Intestine
? Hemistomum pileatum Brandes	Intestine
Strigea cornu (Rud.)	Intestine

125. *Ciconia nigra* (Linn.). Black stork

Chaunocephalus ferox (Zeder)	Intestine
? Echinostomum revolutum (Froelich)	Intestine
Cathaemasia hians (Rud.)	Oesophagus and wall of stomach
Hemistomum excavatum (Rud.)	Intestine

iii. *Plataleae*

Plataleidae

126. *Platalea leucorodia* Linn. Spoonbill

Patagifer bilobus (Rud.)	Intestine
Prosthogonimus putschkowskii Skrjabin	Intestine?
Orchipedum turkestanicum Skrjabin	Trachea

VIII. ARDEIFORMES
iii. *Plataleae* (*continued*)
Ibididae
127. *Plegadis falcinellus* (Linn.). Glossy ibis

Patagifer bilobus (Rud.)	Intestine
Stomylotrema pictum	Intestine

IX. GRUIFORMES
i. *Grues*
Gruidae
128. *Grus grus* (Linn.). Crane
[= *G. communis* Bechst.]

Echinostomum sarcinum Dietz	Intestine
? Echinostomum revolutum Froelich	Intestine
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Hyptiasmus ominosus Kossack	Body cavity and thorax
Hyptiasmus sp. (Kossack)	Trachea
? Typhlocoelum cucumerinum (Rud.)	Thoracic cavity
Cyclocoelum mutabile (Zed.)	Trachea and cavity of sternum
Cyclocoelum adolphi (Stossich)	Oesophagus

X. CHARADRIIFORMES
A. *Otides*
Otididae
129. *Otis tarda* Linn. Great bustard

Prosthogonimus cuneatus (Rud.)	Intestine and Bursa Fabricii
? Prosthogonimus ovatus (Rud.)	Bursa Fabricii

B. *Cursorii*
Glareolidae
130. *Glareola pratincola* (Linn.). Collared pratincole

Stomylotrema perpastum Braun	Cloaca
Eumegacetes emendatus Braun	Cloaca
[= Megacetes triangularis Looss *nec* Dies.]	

C. *Charadrii*
i. *Scolopacinae*
131. *Scolopax rusticola* Linn. Woodcock

Echinostomum revolutum (Froelich)	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Cyclocoelum mutabile	? Trachea
Strigea erratica (Rud.)	Intestine

132. *Gallinago gallinago* (Linn.). Snipe

Himasthla militaris (Rud.)	Intestine
? Echinostomum chloropodis (Zed.)	Intestine
? Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Notocotylus attenuatus (Rud.)	Coeca
"Monostomum angustum" Schlotthauber	? Intestine
? Cyclocoelum mutabile (Zed.)	? Air sacs
Hemistomum spathula Diesing	Intestine
Strigea erratica (Rud.)	Intestine

133. *Gallinago media* (Latham). Great snipe
[= *G. major* Gmel.]

Diplostomum macrostomum Jägerskiöld	Intestine

134. *Limnocryptes gallinula* (Linn.). Jack snipe

? Himasthla militaris (Rud.)	Intestine
Lepoderma nanum (Rud.)	Intestine

X. CHARADRIIFORMES

C. *Charadrii*

i. *Scolopacinae (continued)*

135. *Tringa minuta* Leisler. Little stint	
Stephanoprora pendula (Looss)	Rectum
136. *Tringa maritima* Brünnich. Purple sandpiper	
Maritrema linguilla Jägerskiöld	Intestine
Cyclocoelum vicarium (Arnsdorff)	Pleural cavity
137. *Tringa alpina* Linn. Dunlin	
Himasthla leptosoma (Creplin)	Intestine
Levinseniella brachysoma (Creplin)	Intestine
Spelotrema claviforme (Brandes)	Intestine and rectum
Maritrema gratiosum Nicoll	Intestine
138. *Calidris arenaria* (Linn.). Sanderling	
Himasthla leptosoma (Creplin)	Intestine

ii. *Totaninae*

139. *Machetes pugnax* (Linn.). Ruff	
? Echinostomum revolutum (Froel.)	Intestine
Echinostomum limicoli Johnson	Intestine
? Stephanoprora denticulata (Rud.)	Intestine
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Catotropis verrucosa (Froelich)	Coeca
? Notocotylus attenuatus (Rud.)	Coeca
"Monostomum hyalinum" Schlotthauber	Intestine
Cyclocoelum brasilianum Stossich	Abdominal cavity
140. *Totanus totanus* (Linn.). Redshank	
[= *Totanus calidris* (L.)]	
Cryptocotyle jejuna (Nicoll)	Intestine
Levinseniella brachysoma (Creplin)	Intestine
Maritrema humile Nicoll	Intestine
Cyclocoelum problematicum Stossich	Body cavity
? Cyclocoelum mutabile (Zeder)	? Intestine
141. *Totanus fuscus* (Linn.). Spotted redshank	
Echinostomum sp.	Intestine
(Levinseniella) macrophallos (v. Linstow)	Intestine
? Cyclocoelum mutabile (Zed.)	? Intestine
*142. *Totanus flavipes* (Gmelin). Yellowshank	
Cyclocoelum mutabile (Zed.)	Abdominal cavity and ? infra-orbital sinus
143. *Totanus hypoleucus* (Linn.). Common sandpiper	
Lepoderma vitellatum (v. Linstow)	Intestine
Levinseniella brachysoma (Creplin)	Intestine
(Levinseniella) macrophallos (v. Linstow)	Intestine
Maritrema subdolum Jägerskiöld	Intestine
144. *Totanus ochropus* (Linn.). Green sandpiper	
Echinoparyphium politus Skrjabin	Intestine
Echinoparyphium mordwilkoi Skrjabin	Intestine
Echinoparyphium clerci Skrjabin	Intestine
Catatropis charadrii Skrjabin	Intestine
Cyclocoelum exile (Stossich)	Air sacs
145. *Totanus glareola* (Linn.). Wood sandpiper	
Echinostomum uralense Skrjabin	Intestine
Leucochloridium turanicum (Solowiow)	Intestine
Cyclocoelum orientale Skrjabin	?

X. CHARADRIIFORMES
C. *Charadrii*
ii. *Totaninae* (*continued*)

146. *Limosa limosa* (Linn.). Black-tailed godwit	
Echinostomum academicum Skrjabin	Intestine
147. *Numenius arquata* (Linn.). Curlew	
Himasthla militaris (Rud.) [= Echinostomum tabulatum Mueller]	Intestine
Himasthla rhigedana Dietz	Intestine
? Stephanoprora denticulata (Rud.)	Intestine
Prosthogonimus pellucidus (v. Linstow)	Bursa Fabricii
? Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Spelotrema claviforme (Brandes)	Intestine
Levinseniella sp. (Nicoll)	Intestine
Cyclocoelum vicarium Arnsdorff	Pleural cavity
Cyclocoelum ovopunctatum Stossich	Pleural and abdominal cavities
Cyclocoelum fasciatum (Stossich)	?
Zygocotyle lunatum (Diesing)	Intestine
148. *Numenius phaeopus* (Linn.). Whimbrel	
Pelmatostomum episemum Dietz	Intestine
*149. *Numenius tenuirostris* Vieillot. Slender-billed curlew	
? Stephanoprora denticulata (Rud.)	Intestine
Leucochloridium macrostomum (Rud.)	Intestine

iii. *Himantopodinae*

150. *Himantopus himantopus* (Linn.). Black-winged stilt	
Stephanoprora pendula (Looss)	Intestine
Stomylotrema bijugum Braun	Intestine
Athesmia heterolecithodes (Braun)	Bile duct
Haematotrephus lanceolatus (Wedl)	Abdominal cavity
Cyclocoelum mutabile (Zeder)	Abdominal cavity
151. *Recurvirostra avocetta* Linn. Avocet	
Stephanoprora pendula (Looss)	Intestine and coeca
Echinostomum echiniferum La Val.	Intestine and coeca
Pygorchis affixus Looss	Cloaca
Catatropis verrucosa (Froelich)	Coeca

iv. *Charadriinae*

152. *Charadrius apricarius* Linn. Golden plover (= *C. pluvialis* L.)	
Strigea cornuta (Rud.)	Intestine
*153. *Charadrius dominicus* P. L. S. Müller. American golden plover	
Acanthoparyphium spinulosum S. J. Johnston	Intestine
Levinseniella howensis S. J. Johnston	Intestine
154. *Squatarola squatarola* (Linn.). Grey plover	
Parechinostomum cinctum (Rud.)	Intestine
Stomylotrema fastosum Braun	Intestine
155. *Aegialitis hiaticula* (Linn.). Ringed plover	
Levinseniella brachysoma (Creplin)	Intestine
Levinseniella propinqua Jägerskiöld	Coeca
? Spelotrema claviforme (Brandes)	Intestine
Maritrema gratiosum Nicoll	Intestine
156. *Vanellus vanellus* (Linn.). Lapwing	
Parechinostomum cinctum (Rud.)	Intestine
Echinoparyphium aconiatum Dietz	Intestine
Echinoparyphium politus Skrjabin	Intestine

X. CHARADRIIFORMES
C. *Charadrii*
iv. *Charadriinae*

156. *Vanellus vanellus* Linn. (*continued*)

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Levinseniella brachysoma (Creplin)	Intestine
Notocotylus attenuatus (Rud.)	Intestine and coeca
Cyclocoelum mutabile (Zed.)	Thoracic cavity
"Monostomum vanelli" Stossich	Thoracic cavity
Strigea erratica (Rud.)	Intestine

157. *Haematopus ostralegus* Linn. Oystercatcher

Himasthla leptosoma (Creplin)	Intestine
Psilostomum brevicolle (Creplin)	Intestine
Levinseniella propinqua Jägerskiöld	Coeca and intestine
Levinseniella brachysoma (Creplin)	Coeca and intestine
Spelotrema excellens Nicoll	Intestine
Maritrema gratiosum Nicoll	Intestine
"Distomum minutum" Cobbold	Intestine
Notocotylus attenuatus (Rud.)	Coeca
Monostomum petasatum Deslongchamps	Coeca
"Monostomum ignotum" Nicoll	Intestine

158. *Arenaria interpres* (Linn.). Turnstone

Chloeophora micata Dietz	Intestine
Himasthla leptosoma (Creplin)	Intestine
Echinostephilla virgula Lebour	Intestine
Levinseniella brachysoma (Creplin)	Rectum
(Parorchis) pittacius (Braun)	Intestine
Monostomum petasatum Deslongchamps	Intestine and coeca
Holostomum squamosum Villot	Intestine

XI. LARIFORMES
Laridae

159. *Larus canus* Linn. Common gull

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Gymnophallus deliciosus (Olsson)	Gall-bladder
Parorchis acanthus Nicoll	Rectum
Hemistomum spathaceum (Rud.)	Intestine
Strigea variegata (Creplin)	Intestine and Bursa Fabricii
? Strigea longicollis (Rud.)	Intestine

160. *Larus argentatus* Pantoppidan. Herring gull

Stephanoprora denticulata (Rud.)	Intestine
Himasthla elongata (Mehlis)	Intestine
Parorchis acanthus Nicoll	Rectum and Bursa Fabricii
Parorchis avitus Linton	Bursa Fabricii
Cryptocotyle lingua (Creplin)	Intestine
Spelotrema simile Jägerskiöld	Intestine
Spelotrema excellens Nicoll	Intestine
Maritrema lepidum Nicoll	Intestine
Gymnophallus deliciosus (Olsson)	Gall-bladder
Philophthalmus lucipetus (Rud.)	Nictitating membrane
Clinostomum marginatum (Rud.)	Mouth
Pachytrema calculus Looss	Gall-bladder
Hemistomum spathaceum (Rud.)	Intestine
Strigea variegata (Creplin)	Intestine
? Strigea longicollis (Rud.)	Intestine

XI. LARIFORMES

Laridae (continued)

*161.	*Larus cachinnans* Pall. Yellow-legged herring gull	
	? Strigea longicollis (Rud.)	Intestine
162.	*Larus marinus* Linn. Greater black-backed gull	
	Himasthla elongata (Mehlis)	Intestine
	Stephanoprora denticulata (Rud.)	Rectum
	Cryptocotyle lingua (Creplin)	Intestine
	Lepoderma cirratum (Rud.)	Intestine
	Gymnophallus deliciosus (Olsson)	Gall-bladder
	Hemistomum spathaceum (Rud.)	Intestine
	Strigea variegata (Creplin)	Intestine
163.	*Larus fuscus* Linn. Lesser black-backed gull	
	Stephanoprora denticulata (Rud.)	Intestine
	Cryptocotyle lingua (Creplin)	Intestine
	Spelotrema simile Jägerskiöld	Intestine
	Gymnophallus deliciosus (Olsson)	Gall-bladder
	Philophthalmus lucipetus (Rud.)	Nictitating membrane
	Gigantobilharzia acotylea Odhner	Veins
	Ornithobilharzia intermedia Odhner	Intestinal veins
	[= Bilharzia kowalewskii Par. and Ariola]	
	Strigea variegata (Creplin)	Intestine and Bursa Fabricii
164.	*Larus glaucus* Brünnich. Glaucous gull	
	Stephanoprora denticulata (Rud.)	Intestine
	Cryptocotyle concava (Creplin)	Intestine
	Gymnophallus deliciosus (Olsson)	Gall-bladder
	Philophthalmus lucipetus (Rud.)	Nictitating membrane
	Hemistomum spathaceum (Rud.)	Intestine
*165.	*Larus melanocephalus* Temminck. Mediterranean black-headed gull	
	Ornithobilharzia intermedia Odhner	Intestinal veins
*166.	*Larus philadelphia* (Ord.). Bonaparte's gull	
	Stephanoprora gilberti Ward	Intestinal
167.	*Larus ridibundus* Linn. Black-headed gull	
	Stephanoprora denticulata (Rud.)	Intestine
	Himasthla elongata (Mehlis)	Intestine
	Apophallus mühlingi (Jägerskiöld)	Intestine
	Pachytrema calculus Looss	Gall-bladder
	Spelotrema simile Jägerskiöld	Intestine
	Spelotrema claviforme (Brandes)	Intestine
	Levinseniella sp. (Nicoll)	Intestine
	Maritrema gratiosum Nicoll	Intestine
	Gigantobilharzia acotylea Odhner	Veins
	Monostomum macrostomum Rud.	Intestine
	Hemistomum spathaceum (Rud.)	Intestine
	Strigea variegata (Creplin)	Intestine and Bursa Fabricii
	Strigea bursigera (Brandes)	Intestine
	? Strigea longicollis (Rud.)	Intestine
168.	*Larus minutus* Pallas. Little gull	
	Echinostomum sp.	Intestine
169.	*Rissa tridactyla* (Linn.). Kittiwake	
	Cryptocotyle lingua (Creplin)	Intestine
	Hemistomum spathaceum (Rud.)	Intestine
170.	*Sterna hirundo* Linn. Common tern	
	[= *S. fluviatilis* Naum.]	
	Stephanoprora denticulata (Rud.)	Intestine

XI. LARIFORMES

Laridae

170. *Sterna hirundo* Linn. (*continued*)

Cryptocotyle lingua (Creplin)	Intestine
Hemistomum pileatum (Rud.)	Intestine
Strigea variegata (Creplin)	Intestine and Bursa Fabricii

171. *Sterna paradisea* (Brünnich). Arctic tern
[= *S. macrura* Naum.]

Hemistomum pileatum (Rud.)	Intestine

172. *Sterna dougalli* Montagu. Roseate tern

Cryptocotyle lingua (Creplin)	Intestine

173. *Sterna minuta* Linn. Little tern

Microlistrum cochlear Diesing	Intestine

174. *Sterna caspia* Pallas. Caspian tern

Stephanoprora denticulata (Rud.)	Rectum
Hemistomum pileatum (Rud.)	Intestine

175. *Sterna sandvicensis* Latham. Sandwich tern
[= *S. cantiaca* Gmelin]

Stephanoprora denticulata (Rud.)	Intestine
? Stephanoprora pendula (Looss)	Intestine
Microlistrum cochlear (Rud.)	Intestine
Microlistrum cochleariforme (Diesing)	Intestine
Hemistomum pileatum (Rud.)	Intestine

176. *Hydrochelidon nigra* (Linn.). Black tern

Stephanoprora denticulata (Rud.)	Intestine
Echinoparyphium clerci Skrjabin	Intestine
Cathaemasia fodicans Braun	Intestine

177. *Stercorarius parasiticus* (Linn.). Richardson's skua

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Strigea variegata (Creplin)	Intestine and Bursa Fabricii

178. *Stercorarius pomarinus* (Temminck). Pomatorhine skua

Strigea variegata (Creplin)	Intestine and Bursa Fabricii

XII. ALCIFORMES

Alcidae

179. *Alca torda* Linn. Razorbill

Stephanoprora denticulata (Rud.)	Intestine
Metorchis xanthosomus (Creplin)	Gall-bladder
Cryptocotyle concava (Creplin)	Intestine
? Cryptocotyle lingua (Creplin)	Intestine
Sphaeridiotrema globulus (Rud.)	Intestine
Hemistomum pileatum (Rud.)	Intestine
Strigea variegata (Creplin)	Intestine
Strigea erratica (Rud.)	Intestine

180. *Uria troille* (Linn.). Common guillemot

Strigea variegata (Creplin)	Intestine
Strigea erratica (Rud.)	Intestine

181. *Uria grylle* (Linn.). Black guillemot

Prosthogonimus ovatus	Bursa Fabricii
Echinostomum sp. (Dietz)	Intestine

XIII. PROCELLARIFORMES

Puffinidae

*182. *Puffinus kuhli* (Boie). Mediterranean great shearwater

Echinostomum magniovatum Stoss.	Intestine

XIV. COLYMBIFORMES

Colymbidae

183. *Podiceps cristatus* (Linn.). Great crested grebe

? Echinostomum revolutum (Froelich)	Intestine
Echinostomum paraulum Dietz	Intestine
Echinochasmus coaxatus Dietz	Intestine
Stephanoprora spinosa Odhner	Intestine
(Echinostomum?) intermedium Mehlis	Intestine
Cryptocotyle concava (Creplin)	Intestine and coeca
Taphrogonimus holostomoides (Creplin)	Intestine
Renicola pinguis (Creplin)	Kidney
Hemistomum (? pileatum Rud.)	Intestine
? Strigea variegata (Creplin)	Intestine and Bursa Fabricii
"Holostomum coniferum" Mehlis	Intestine

184. *Podiceps griseigena* (Boddaert). Red-necked grebe
[= *P. rubricollis* Lath. = *P. subcristatus* Bechst.]

Echinochasmus coaxatus Dietz	Intestine
Stephanoprora spinosa Odhner	Intestine and coeca
(Echinostomum?) intermedium Mehlis	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii

185. *Podiceps auritus* (Linn.). Slavonian grebe

? Heterechinostomum mordax (Looss)	Intestine
Cryptocotyle lingua (Creplin)	Intestine
Distomum capsulare Diesing	Encysted in muscles

186. *Podiceps nigricollis* Brehm. Black-necked grebe

Cryptocotyle concava (Creplin)	Intestine and coeca
Distomum capsulare Diesing	Encysted in muscles

187. *Podiceps fluviatilis* (Tunstall). Little grebe
[= *P. minor* Lath. = *Colymbus nigricans* Scop.]

Echinostomum pungens v. Linstow	Intestine
? Metorchis xanthosomus (Creplin)	Gall-bladder
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii

188. *Colymbus arcticus* Linn. Black-throated diver

Stephanoprora denticulata (Rud.)	Intestine
? Stephanoprora spinosa Odhner	Intestine
Eucotyle nephritica (Creplin)	Kidney
Hemistomum sp. (Lühe)	Intestine
Strigea variegata (Creplin)	Intestine and Bursa Fabricii
Strigea erratica (Rud.)	Intestine and Bursa Fabricii

189. *Colymbus immer* Brünnich. Great northern diver
[= *C. glacialis* Linn.]

Cryptocotyle lingua (Creplin)	Intestine
Hemistomum pileatum Brandes	Intestine
Hemistomum gavium Guberlet	Intestine
Strigea gracilis (Rud.)	Intestine
Strigea agnavis Guberlet	Intestine

190. *Colymbus stellatus* Pontoppidan. Red-throated diver
[= *C. septentrionalis* Linn.]

Echinoparyphium baculus Diesing	Intestine
Stephanoprora spinosa Odhner	Intestine
Metorchis xanthosomus (Creplin)	Intestine
Cryptocotyle concava (Creplin)	Intestine
? Hemistomum pileatum Brandes	Intestine
? Strigea variegata (Creplin)	Intestine and Bursa Fabricii
Strigea erratica (Rud.)	Intestine and Bursa Fabricii

XV. RALLIFORMES

Rallidae

191. *Rallus aquaticus* Linn. Water-rail

Leucochloridium macrostomum (Rud.)	Rectum
Notocotylus attenuatus (Rud.)	Coeca and rectum
? Notocotylus diserialis Ssinizin	Intestine
Cyclocoelum mutabile (Zeder)	Thoracic cavity and abdomen
Monostomum sp. (Lühe)	Infra-orbital sinus

192. *Porzana porzana* (Linn.). Spotted crake

Echinostomum chloropodis (Zeder)	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Leucochloridium macrostomum (Rud.)	Rectum
Notocotylus attenuatus (Rud.)	Intestine and coeca
Catatropis verrucosa (Froelich)	Intestine and coeca

193. *Porzana pusilla intermedia* Hermann. Baillon's crake

Ophthalmophagus singularis Stoss.	Conjunctival sac

194. *Crex crex* (Linn.). Corncrake

Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Distomum capsulare Dies.	Encysted in muscles
Catatropis verrucosa (Froelich)	Intestine

195. *Gallinula chloropus* (Linn.). Moorhen

Echinostomum chloropodis (Zeder)	Intestine
Parechinostomum cinctum (Rud.)	Intestine
Psilotrema oligoon (v. Linstow)	Intestine
Leucochloridium macrostomum (Rud.)	Rectum
? Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Athesmia heterolecithodes (Braun)	Liver
Distomum polyoon v. Linstow	Intestine
Notocotylus attenuatus (Rud.)	Intestine and coeca
Notocotylus gibbus (Mehlis)	Intestine
Cyclocoelum mutabile (Zeder)	Abdominal cavity

196. *Fulica atra* Linn. Coot

Echinostomum anceps (Molin)	Intestine
Patagifer bilobus (Rud.)	Intestine
? Stephanoprora denticulata (Rud.)	Intestine
Prosthogonimus ovatus (Rud.)	Bursa Fabricii
Prosthogonimus cuneatus (Rud.)	Bursa Fabricii
Schistogonimus rarus (Braun)	Bursa Fabricii
Leucochloridium insigne (Looss)	Cloaca
Apopharynx bolodes (Braun)	Bursa Fabricii
(Phaneropsolus) arenula (Creplin)	Intestine
Notocotylus attenuatus (Rud.)	Intestine and coeca
Notocotylus gibbus (Mehlis)	Intestine
Catatropis verrucosa (Froelich)	Intestine
Cyclocoelum microstomum (Creplin)	Thoracic and body cavities
Hyptiasmus oculeus Kossack	Infra-orbital sinus

XVI. COLUMBIFORMES

Columbidae

197. *Columba palumbus* Linn. Wood pigeon

? Harmostomum mesostomum (Rud.)	Intestine

198. *Columba livia* Gmelin. Rock dove

Harmostomum mesostomum (Rud.)	Intestine
(Echinostomum) sp. (Mueller)	Intestine

XVII. GALLIFORMES

i. *Phasianidae*

199. *Coturnix coturnix* (Linn.). Pheasant

Harmostomum fuscatum (Rud.)	Intestine
(Clinostomum) heteroclitum Molin	? Coeca

ii. *Tetraonidae*

200. *Lyrurus tetrix* Linn. Black grouse

Lyperosomum corrigia Braun	Intestine

LIST OF BRITISH BIRDS IN WHICH NO TREMATODE PARASITES HAVE HITHERTO BEEN RECORDED

PASSERIFORMES

Corvidae

1. Pyrrhocorax pyrrhocorax L.	Chough

Sturnidae

2. Pastor roseus (L.)	Rose-coloured pastor

Fringillidae

3. Carduelis carduelis (L.)	Continental goldfinch
4. Serinus serinus (L.)	Serin
5. Fringilla montifringilla L.	Brambling
6. Acanthis cannabina (L.)	Linnet
7. Acanthis flavirostris (L.)	Twite
8. Carpadocus erythrinus (Pallas)	Scarlet grosbeck
9. Loxia curvirostra L.	Crossbill
10. Emberiza calandra L.	Corn bunting
11. Emberiza hortulana L.	Ortolan bunting
12. Emberiza pusilla Pallas	Little bunting
13. Emberiza schoeniclus L.	Reed bunting
14. Calcarius lapponicus (L.)	Lapland bunting
15. Plectrophenax nivalis (L.)	Snow bunting

Alaudidae

16. Alauda arvensis L.	Skylark
17. Lullula arborea (L.)	Wood-lark
18. Otocorys alpestris (L.)	Shore-lark

Motacillidae

19. Motacilla lugubris Temminck	Pied wagtail
20. Motacilla raii (Bonaparte)	Yellow wagtail
21. Anthus trivialis L.	Tree pipit
22. Anthus pratensis L.	Meadow pipit
23. Anthus campestris L.	Tawny pipit
24. Anthus richardi Vieillot	Richard's pipit
25. Anthus spinoletta (L.)	Water pipit

Certhiidae

26. Certhis familiaris L.	Tree creeper

Sittidae

27. Sitta caesia Wolf	Nuthatch

Regulidae

28. Regulus regulus (L.)	Gold crest
29. Regulus ignicapillis (Temminck)	Fire crest

Panuridae

30. Panurus biarmicus (L.)	Bearded titmouse

PASSERIFORMES (*continued*)

Paridae

31.	Parus ater L.	Coal titmouse
32.	Parus borealis Selys-Longchamps	Willow titmouse
33.	Parus cristatus L.	Crested titmouse
34.	Aegitholus caudatus (L.)	White-headed long-tailed titmouse

Laniidae

35.	Lanius serrator L.	Woodchat

Ampelidae

36.	Ampelis garrulus (L.)	Waxwing

Sylviidae

37.	Sylvia curruca (L.)	Lesser whitethroat
38.	Sylvia atricapilla (L.)	Blackcap
39.	Melizophilus undatus dartfordiensis (Latham)	Dartford warbler
40.	Agrobates galactodes (Temminck)	Rufous warbler
41.	Locustella naevia (Bodd.)	Grasshopper warbler
42.	Acrocephalus streperus (Vieillot)	Reed warbler
43.	Acrocephalus palustris (Bechst.)	Marsh warbler
44.	Acrocephalus schoenobaenus (L.)	Sedge warbler
45.	Acrocephalus aquaticus (Gmel.)	Aquatic warbler
46.	Hypolais icterina (Vieillot)	Icterine warbler
47.	Phylloscopus collybita (Vieillot)	Chiffchaff
48.	Phylloscopus tristis Blyth	Siberian chiffchaff
49.	Phylloscopus superciliosus (Gmelin)	Yellow-browed warbler

Turdidae

50.	Turdus pilaris L.	Fieldfare
51.	Turdus torquatus L.	Ring-ouzel
52.	Turdus aureus Holandre	White's thrush
53.	Phoenicurus tithys (Bechst.)	Black redstart
54.	Erithacus rubecula (L.)	Redbreast
55.	Cyanosylvia suecica (L.)	Red-spotted bluethroat
56.	Saxicola rubicola (L.)	Stonechat
57.	Saxicola rubetra (L.)	Whinchat
58.	Accentor collaris (Scopoli)	Alpine accentor

Cinclidae

59.	Cinclus cinclus (L.)	Dipper

Troglodytidae

60.	Troglodytes troglodytes (L.)	Wren

Muscicapidae

61.	Muscicapa grisola L.	Spotted flycatcher
62.	Muscicapa atricapilla L.	Pied flycatcher
63.	Muscicapa parva Bechst.	Red-breasted flycatcher

PICIFORMES

Pici

Picidae

64.	Dryobates major (L.)	Great spotted woodpecker
65.	Dryobates minor (L.)	Lesser spotted woodpecker
66.	Picus viridis L.	Green woodpecker
67.	Iynx torquilla L.	Wryneck

COCCYGES

Cuculi

Cuculidae

68.	Cuculus canorus L.	Cuckoo

ACCIPITRIFORMES

Falconidae

69. Hierofalco islandus (Brünn)	Iceland falcon
69 *a*. Aquila fusca Brehm	Spotted eagle

ANSERIFORMES

Anatidae

70. Anser brachyrhynchus Baillon	Pink-footed goose
71. Chen hyperboreus (Pallas)	Snow goose
72. Cygnus bewicki Yarrell	Bewick's swan
73. Tadorna casarca (Linn.)	Ruddy sheld duck
74. Oedemia perspicillata (Linn.)	Surf-scoter

ARDEIFORMES

75. Ardeola ralloides (Scopoli)	Squacco heron
76. Botaurus lentiginosus (Montagu)	American bittern

CHARADRIIFORMES

77. Otis tetrax Linn.	Little bustard
78. Oedicnemus oedicnemus (Linn.)	Stone curlew
79. Cursorius gallicus (Gmel.)	Cream-coloured courser
80. Phalaropus fulicarius (Linn.)	Grey phalarope
81. Phalaropus lobatus (Linn.)	Red-necked phalarope
82. Tringa canutus Linn.	Knot
83. Tringa temmincki Leisler	Temminck's stint
84. Tringa maculata Vieillot	American pectoral sandpiper
85. Tringa ferruginea Brünnich	Curlew sandpiper
86. Totanus nebularis (Gunn)	Greenshank
87. Macrorhamphus griseus (Gmelin)	Red-breasted snipe
88. Limosa lapponica (Linn.)	Bar-tailed godwit
89. Aegialitis alexandrina (Linn.)	Kentish plover
90. Eudromias morinellus (Linn.)	Dotterel

LARIFORMES

91. Larus leucopterus Fabr.	Iceland gull
92. Xema sabinei (Sabine)	Sabine's gull
93. Pagophila eburnea Phipp	Ivory gull
94. Sterna anglica Montagu	Gull-billed tern
95. Hydrochelidon leucoptera (Temminck)	White-winged black tern
96. Catharacta skua Brünn.	Great skua
97. Stercorarius longicauda Vieillot	Buffon's skua

ALCIFORMES

98. Alle alle (Linn.)	Little auk
99. Fratercula arctica (Linn.)	Puffin

PROCELLARIFORMES

100. Thalassodroma pelagica (Linn.)	Storm petrel
101. Oceanodroma leucorrhoa (Vieillot)	Leach's petrel
102. Puffinus puffinus (Brünnich)	Manx shearwater
103. Puffinus griseus (Gmelin)	Sooty shearwater
104. Puffinus gravis O'Reilly	Greater shearwater
105. Fulmarus glacialis (Linn.)	Fulmar

RALLIFORMES

106. Porzana parva (Scop.)	Little crake

COLUMBIFORMES

107. Columba oenas Linn.	Stock dove
108. Streptopelia turtur (Linn.)	Turtle dove

PTEROCLETIFORMES

109. Syrrhaptes paradoxus (Pallas)	Pallas's sand grouse

GALLIFORMES

110. Phasianus colchicus Linn.	Pheasant
111. Caccabis rufa (Linn.)	Red-legged partridge
112. Perdix perdix Linn.	Partridge
113. Tetrao urogallus Linn.	Capercaillie
114. Lagopus scoticus (Latham)	Red grouse
115. Lagopus mutus (Montm.)	Ptarmigan

REFERENCES.

ARNSDORFF, A. (1908). *Monostomum vicarium* n. sp. *Centralbl. f. Bakt.* 1ste Abt. XLVII, 362–6.

BARKER, F. D. (1911). The Trematode Genus *Opisthorchis* R. Blanchard 1895. *Archiv. de Parasitol.* XIV, 513–61.

BLANCHARD, R. (1895). Animaux parasites. *Bull. Soc. Zool. France*, XX, 217.

BRANDES, G. (1888). *Die Familie der Holostomeae.* pp. 72. Leipzig.

—— (1889). Helminthologisches. *Arch. f. Naturg.* LIV, 247–51.

—— (1890). Die Familie der Holostomiden. *Zool. Jahrb., Syst.* V, 549–604.

—— (1892). Revision der Monostomiden. *Centralbl. f. Bakt.* 1ste Abt. XII, 504–11.

BRAUN, M. (1893). "Vermes," in *Bronn's Klassen und Ordnung des Thier-Reichs*, IV, 819–903.

—— (1900). Die Arten der Gattung *Clinostomum* Leidy. *Zool. Jahrb., Syst.* XIV, 1–48.

—— (1901 *a*). Trematoden der Bursa Fabricii, des Eileiters und der Eier der Vögel. *Centralbl. f. Bakt.* 1ste Abt. XXIX, 12–19.

—— (1901 *b*). Zur Revision der Trematoden der Vögel. *Ibid.* 560–8, 895–7, 941–8.

—— (1902). Fascioliden der Vögel. *Zool. Jahrb., Syst.* XVI, 1–162.

CIUREA, J. (1911). Eine europäische Clinostomum-Larve. *Centralbl. f. Bakt.* 1ste Abt. LX, 354–8.

COBBOLD, T. S. (1859). On some new forms of Entozoa. *Trans. Linn. Soc.* London, XXII, 363–6.

—— (1860). Synopsis of the Distomidae. *Journ. Proc. Linn. Soc. Zool.* (17), V, 1–56.

COHN, L. (1904). Helminthologische Mitteilungen II. *Archiv. f. Naturg.* (i), 232.

COLE, L. J. (1911). A Trematode Parasite of the English sparrow in the United States. *Bull. Wiscon. Nat. Hist. Soc.* Milwaukee, IX, 42–8.

CREPLIN, F. C. H. (1829). *Novae observationes de Entozois.* pp. 134. Berlin.

—— (1837). "Distoma," in *Allgemein. Encyclopaed. d. Wissenschaft. u. Künste* (Ersch und Gruber), Leipzig, XXIX, 309–29.

—— (1846). Nachträge zu Gurlt's Verzeichnis der Tiere, bei welchen Entozoen gefunden worden sind. *Arch. f. Naturg.* XII, 129–60.

—— (1849). Nachträge u.s.w. *Ibid.* XV, 52–80.

DESLONGCHAMPS, E. E. (1824). "Monostome," in *Encyclopaedia méthodique*, Paris, II, 551–5.

DIESING, K. M. (1836). Monographie der Gattungen Amphistoma und Diplodiscus. *Ann. Wien Mus. Naturg.* I, 235–60.

—— (1850). *Systema Helminthum.* 2 vols. Vindobonae.

—— (1855). Neunzehn Arten von Trematoden. *Denkschr. d. k. Akad. Wissenschaft. Wien, Math.-Naturwiss. Cl.* X, 59–70.

—— (1858). Revision der Myzhelminthen. Abt. Trematoden. *Sitzungsber. d. k. Akad. Wissenschaft. Wien, Math.-Naturwiss. Cl.* XXXII, 207–390.

DIETZ, E. (1909). Die Echinostomiden der Vögel. *Zool. Anzeig.* XXXIX, 180–92.

—— (1910). Die Echinostomiden der Vögel. *Zool. Jahrb., Syst.* XII, Suppl. 265–512.

DUJARDIN, F. (1845). *Histoire naturelle des Helminthes.* Paris.

FISCHOEDER, F. (1903). Die Paramphistomiden der Säugethiere. *Zool. Jahrb., Syst.* XVII, 485–660.

FUHRMANN, O. (1919). Notes helminthologiques suisses II. *Rev. Suisse Zool. Génève*, XXVII, 353–76.

GIARD, A. (1907). Sur les Trématodes margaritigènes du Pas-de-Calais; *Gymnophallus somateriae* Levins. et *G. bursicola* Odhner. *C. R. Soc. Biol.* LXIII, 416–20.

GIEBEL, C. (1857). Nitzsch's helminthologische Untersuchungen. *Zeitschr. f. d. gesammt. Naturw.* Berlin, IX, 264–9.

GILBERT, N. C. (1905). Occurrence of *Echinostomum spinulosum* Rud. *Amer. Naturalist*, XXXIX, 925–7.

GOLDBERGER, J. and CRANE, C. (1911). A new species of *Athesmia* (*A. foxi*) from a monkey. *U.S. Hyg. Lab., Bull.* 71, pp. 48–55.

GUBERLET, J. E. (1922). *Journ. of Parasitology*, IX, 6–14.

JÄGERSKIÖLD, L. A. (1896). Ueber *Monostomum lacteum* n. sp. *Festskrift för Lilljeborg*, pp. 167–77.

—— (1898). *Distomum lingua* Creplin, ein genitalnapftragendes Distomum. *Bergens Museums Aarborg*, No. II. pp. 7.

—— (1900 *a*). *Diplostomum macrostomum* n. sp. *Centralbl. f. Bakt.* (i), XXVII, 33–37.

—— (1900 *b*). *Levinsenia* (*Distomum*) *pygmaea* Levinsen, ein genitalnapftragendes Distomum. *Ibid.* pp. 732–40.

—— (1901). *Tocotrema expansum* (Crepl.) (= *Monostomum expansum* Crepl.), eine genitalnapftragende Distomide. *Ibid.* XXX, 979–83.

—— (1903). *Scaphanocephalus expansus* (Crepl.), eine genitalnapftragende Distomide. *Results of Swedish Zool. Exped. Egypt and the White Nile*, No. 23. pp. 16.

—— (1907). Zur Kenntnis der Trematoden-Gattung *Levinseniella*. *Zool. Stud. till T. Tullberg*, Uppsala, pp. 133–54.

—— (1908). Kleine Beiträge zur Kenntnis der Vogeltrematoden. *Centralbl. f. Bakt.* XLVIII, 302–17.

JAMESON, H. L. and NICOLL, W. (1913). On some parasites of the Scoter duck (*Oidemia nigra*) and their relation to the pearl-inducing Trematode in the edible mussel (*Mytilus edulis*). *Proc. Zool. Soc.* London, pp. 53–63.

JEGEN, C. (1917). *Collyriclum faba* (Bremser) Kossack. Ein Parasit der Singvögel. *Zeitschr. f. wissenschaft. Zool.* CXVII, 460–553.

JOHNSON, J. C. (1920). The Life-Cycle of *Echinostomum revolutum* (Froelich). *Univ. of California Publications in Zoology*, XIX, 335–88.

JOHNSTON, S. J. (1914). Australian Trematodes and Cestodes, a study in Zoo-Geography. *Medical Journ. of Australia*, Sept. 12th. pp. 5.

—— (1917). On the Trematodes of Australian Birds. *Journ. R. Soc. New South Wales*, L, 187–261.

KOSSACK, W. (1911). Ueber Monostomiden. *Zool. Jahrb., Syst.* XXXI, 491–590.

KOWALEWSKI, M. (1898 *a*). Études helminthologiques V. Contribution à l'étude de quelques Trématodes. *Bull. Acad. Sci. Cracovie*, pp. 69–77.

—— (1898 *b*). Über *Opisthorchis pianae* Galli-Valerio. *Centralbl. f. Bakt.* XXIII, 751–2.

—— (1902). Materials for Polish helminthological parasitic fauna III. *Sprawoz. Kom. fizyogr. Akad.* Krakow, XXXVI, 21–30.

—— (1903). Helminthological Studies VII. *Bull. Acad. Sci. Cracovie*, pp. 517–20.

KRAUSE, R. (1914). Beitrag zur Kenntnis der Hemistominen. *Zeitschr. f. wissenschaft. Zool.* CXII, 93–228.

LAWROW, S. (1908). Resultate der Untersuchungen der Würmer Fauna des Wolga-Flusses und der Wiesen-Seen bei Saratow. *Arbeiten aus der biologischen Wolga-Station*, III, No. 3.

LEBOUR, M. V. (1909). Trematodes of the Northumberland Coast, No. III. *Trans. Nat. Hist. Soc. Northumberland*, III, 440–5.

LEBOUR, M. V. (1912). A Review of the British Marine Cercariae. *Parasitology*, IV, 416–56.

LEBOUR, M. V. and ELMHIRST, R. (1922). A Contribution towards the Life-history of *Parorchis acanthus* Nicoll. *Journ. Mar. Biol. Assoc.* Plymouth, XII, 829–32.

VON LINSTOW, O. (1873). Einige neue Distomen und Bemerkungen über die weiblichen Sexualorgane der Trematoden. *Arch. f. Naturg.* XXXIX, 95–108.

—— (1875). Beobachtungen an neuen und bekannten Helminthen. *Ibid.* XLI, 183–207.

—— (1877). Enthelminthologica. *Ibid.* XLIII, 173–98.

—— (1878 and 1889). *Compendium der Helminthologie* and *Nachtrag*. Hannover; Hahn'sche Buchhandlung.

—— (1883). Nematoden, Trematoden und Acanthocephalen gesammelt von Prof. Fedtschenko in Turkestan. *Arch. f. Naturg.* XLIX, 274–314.

—— (1885). Beobachtungen an bekannten und neuen Nematoden und Trematoden. *Ibid.* LI, 235–55.

—— (1887). Helminthologische Untersuchungen. *Zool. Jahrb., Syst.* III, 97–114.

—— (1894). Helminthologische Studien. *Zeitschr. f. Naturwiss.* Jena, XXVIII, 328–42.

—— (1904). Über eine neue Art der Copula bei Distomen. *Zool. Anzeig.* XXVIII, 252–4.

—— (1906). Neue und bekannte Helminthen. *Zool. Jahrb., Syst.* XXIV, 1–20.

LINTON, E. (1914). Notes on a viviparous Distome. *Proc. U.S. Nat. Mus.* XLVI, 551–5.

—— (1915). *Tocotrema lingua* (Creplin). The adult stage of a skin parasite of the Cunner, etc. *Journ. of Parasitology*, I, 128–34.

LOOSS, A. (1896). Recherches sur la faune parasitaire de l'Egypte. *Mém. Inst. Egypt.* III.

—— (1899). Weitere Beiträge zur Kenntnis der Trematoden-Fauna Aegyptens. *Zool. Jahrb., Syst.* XII, 521–784.

—— (1902). Über neue und bekannte Trematoden aus Seeschildkröten. *Ibid.* XVI, 411–894.

—— (1907 *a*). Über einige zum Teil neue Distomen der europäischen Fauna. *Centralbl. f. Bakt.* XLIII, 604–13.

—— (1907 *b*). Notizen zur Helminthologie Aegyptens VII. Über einige neue Trematoden der ägyptischen Fauna. *Ibid.* pp. 478–90.

LÜHE, M. (1898). Beiträge zur Helminthfauna der Berberei. *Sitzungsber. d. k. preuss. Akad. Wissenschaft.* Berlin, XL, 619–28.

—— (1908). Zur Systematik und Faunistik der Distomen. I. Die Gattung *Metorchis* Looss nebst Bemerkungen über die Familie Opisthorchiidae. *Centralbl. f. Bakt.* XLVIII, 428–36.

—— (1909). "Parasitische Plattwürmer. Trematodes," in *Die Susswasserfauna Deutschlands*, XVII.

MARKOW, M. (1903). Sur un nouveau représentant du genre *Prostogonimus—P. anatinus* n. sp. *Trav. soc. nat. Univ. Kharkov*, XXXVII, 287–94.

MOLIN, R. (1858). Prospectus helminthum, quae in prodromo faunae helminthologicae Venetiae continentur. *Sitzungsber. d. k. Akad. Wissenschaft. Wien, Math.-Naturw. Cl.* XXX, 127–58.

—— (1859 *a*). Prospectus helminthum quae in parte secundo continentur. *Ibid.* XXXIII, 287–302.

—— (1859 *b*). Nuovi myzelmintha raccolti ed esaminati. *Ibid.* XXXVII, 818–54.

—— (1861). Prodromus faunae helminthologicae Venetae adjectis disquisitionibus anatomicis et criticis. *Denkschr. d. k. Akad. d. Wissenschaft. Wien, Math.-Naturw. Cl.* XIX, 189–338.

MÜHLING, P. (1896). Beiträge zur Kenntnis der Trematoden. *Arch. f. Naturg.* LXII, 243–79.

—— (1898). Die Helminthfauna der Wirbelthiere Ostpreussens. *Ibid.* LXIV, 1–118.

MUELLER, A. (1897). Helminthologische Mitteilungen. *Ibid.* LXIII, 1–26.

NICOLL, W. (1906). Some new and little-known Trematodes. *Ann. and Mag. Nat. Hist.* (7), XVII, 513–27.

—— (1907 *a*). Observations on the Trematode Parasites of British Birds. *Ibid.* (7), XX, 66–94.

NICOLL, W. (1907 *b*). *Parorchis acanthus*, the type of a new genus of Trematodes. *Quart. Journ. Micros. Science*, LI, 345–55.

—— (1909). Studies on the Structure and Classification of the Digenetic Trematodes. *Ibid.* LIII, 391–487.

—— (1910). The Bionomics of Helminths. *Trans. Soc. Trop. Med.* III, 353–78.

—— (1915). A new liver fluke (*Platynosomum acuminatum*) from the Kestrel. *Proc. Zool. Soc.* London, pp. 87–90.

ODHNER, T. (1900). Gymnophallus, eine neue Gattung von Vogeldistomen. *Centralbl. f. Bakt.* XXVIII, 12–23.

—— (1905). Die Trematoden des arktischen Gebietes. *Fauna Arctica*, IV (2), 291–372.

—— (1910 *a*). Nordostafrikanische Trematoden, grösstenteils vom Weissen Nil. i Fascioliden. *Results of Swedish Zool. Exped. Egypt and the White Nile* (1907), IV, No. 23 A. pp. 166.

—— (1910 *b*). *Microlistrum* Braun, eine angebliche Distomengattung. *Zool. Anzeig.* XXXV, 353–6.

—— (1910 *c*). Gigantobilharzia acotylea n. g., n. sp., ein mit den Bilharzien verwandte Blutparasit von enormer Länge. *Ibid.* pp. 380–5.

—— (1912). Zum natürlichen System der digenen Trematoden V. *Ibid.* XLI, 54–71.

—— (1913). Zum natürlichen System der digenen Trematoden VI. *Ibid.* XLII, 289–318.

—— (1914). Die Verwandtschaftsbeziehungen der Trematodengattung *Paragonimus* Brn. *Zool. Beiträge aus Uppsala*, III, 231–46.

OLSSON, P. (1876). Bidrag til Skand. Helminthfauna. *Svensk. Vetensk. Akad. Handl.* Stockholm, XIV (i). pp. 35.

—— (1893). Bidrag til Skand. Helminthfauna II. *Ibid.* XXV, No. 12.

OSBORN, H. L. (1911). On the Distribution and Mode of Occurrence in the United States and Canada of *Clinostomum marginatum*, a Trematode parasite of fish, frogs and birds. *Biol. Bull., Woods Hole, Mass.* XX, 350–66.

—— (1912). On the structure of *Clinostomum marginatum*, a Trematode parasite of the Frog, Bass and Heron. *Journ. Morph.* XXIII, 189–223.

PELSENEER, P. (1906). Trématodes parasites de Mollusques marins. *Bull. scient. France et Belg.* XL, 1–186.

PRATT, H. S. (1911). On *Galactosomum cochleariforme* Rudolphi. *Zool. Anzeig.* XXVIII, 143–8.

RAILLIET, A. (1900). Trématodes hepatiques des oiseaux. *C.R. Soc. Biol.* LII, 239–42.

RANSOM, B. H. (1920). Synopsis of the Trematode Family Heterophyidae, with descriptions of a new genus and four new species. *Proc. U.S. Nat. Mus.* LVII, 527–73.

RÀTZ, S. VON (1900 *a*). Parasitologioi jegyzetek. *Veterinarius*, Budapest, XXIII, 525–34.

—— (1900 *b*). Über *Distomum saginatum* n. sp. *Centralbl. f. Bakt.* (i), XXVIII, 437–9.

—— (1903). Un genre nouveau de fasciolides. *Ann. Mus. Nat. Hungar.* Budapest, I, 413–32.

RUDOLPHI, C. A. (1808–10). *Entozoorum sive vermium intestinalium historia naturalis.* pp. 1370. Amsterdam.

—— (1819). *Entozoorum Synopsis cui accedunt mantissa duplex et indices locupletissimi.* pp. 811. Berlin.

SALZER, F. (1907). Anatomische Untersuchungen über den Wurmstar der Fische. *Arch. Augenheilkunde*, Wiesbaden, LVIII, 19–39.

SCHLOTTHAUBER, C. (1860). Beiträge zur Helminthologie. *Amtl. Bericht.* 31ste *Versamml. deutsch. Naturf. und Aerzte*, Göttingen, pp. 121–33.

SKRJABIN, K. I. (1912). Parasitische Würmer der Vögel Turkestans. A. Trematodes. 1. Prosthogoniminae. *Arch. veterin. nauk.* St Petersburg, XLII, 1270–87.

—— (1913 *a*). Vogeltrematoden aus russisch Turkestan. *Zool. Jahrb., Syst.* XXXV, 351–88.

—— (1913 *b*). Parasitische Würmer der Vögel Turkestans. A. Trematodes. 2. Orchipedinae. *Arch. veterin. nauk.* St Petersburg, XLIII, 339–44.

SKRJABIN, K. I. (1914). *Lyperosomum filiforme* n. sp. Materialien zur Systematik der Gattung *Lyperosomum* Looss 1899. *Zeitschr. f. wissen. u. prakt. Veterinar. Med.* VII, 274–91.

—— (1915 *a*). Trématodes des oiseaux de l'Oural. *Ann. Mus. Zool. Acad. Imp. Sc.* XX, 395–417.

—— (1915 *b*). Ein neuer Parasit der Bursa Fabricii der Vögel. *Rev. véter. Moskva*, XVII, 238–9.

—— (1916). *Parasitic Trematodes and Nematodes collected by the Expedition of Prof. V. Dogiel and I. Sokolow in British East Africa.* pp. 59.

SOLOWIOW, P. T. (1911). Eine neue Art des Genus *Dicrocoelium* Dujardin und eine Excursion in Gebiet der Systematik und Phylogenie der Fasciolidae der Vögel. *Arbeit. zool. Labor. Univ. Warschau* 1911. pp. 23.

—— (1912). Vers parasitaires des oiseaux du Turkestan. *St Pétersbourg Ann. Mus. Zool. Acad. Imp. Sc.* XVII, 86–115.

SSINIZIN, D. F. (1897). Endoparasiten der Vögel aus der Umgebend Warschau. *Arb. Labor. zool. Kab. Univ. Warschau*, pp. 1–20.

STILES, C. W. (1901). Notes on Parasites 53. *Science*, N.S. XIII, 593.

STILES, C. W. and HASSALL, A. (1896). Notes on Parasites 42. *The Veterinary Magazine*, III, No. 3.

STOSSICH, M. (1892). I Distomi degli Uccelli. Lavoro Monografico. *Boll. Soc. Adriat. sc. nat.* Trieste, XIII, 143–96.

—— (1896). Ricerche elmintologiche. *Ibid.* XVII, 121–36.

—— (1898 *a*). Note parassitologiche. *Ibid.* XVIII, 1–10.

—— (1898 *b*). Saggio di una fauna elmintologica di Trieste e provincie cotermini. *Program. civ. scuola sup.* Trieste. pp. 162.

—— (1902). Il *Monostomum mutabile* Zeder e le sui formi affini. *Boll. Soc. Adriat. sc. nat.* Trieste, XXI, 1–40.

—— (1903). Note distomologiche. *Ibid.* XXI, 193–201.

—— (1905). Note distomologiche III. *Ibid.* XXII, 211–27.

STUNKARD, H. W. (1916). On the Anatomy and Relationships of some North American Trematodes. *Journ. of Parasitology*, III, 21–27.

THOSS, E. (1897). *Über den Bau von Holostomum cucullus nov. spec. Ein Beitrag zur Kenntnis der Trematoden.* Leipzig, Inaug. Dissert. pp. 66.

LA VALETTE, A. J. H. (1855). *Symbolae ad trematodum evolutionis historiam.* pp. 38. Berlin.

VILLOT, F. (1878). Organisation et développement de quelques espèces de trématodes endoparasites marins. *Ann. sc. nat. Paris, zool.* XLIX, pp. 40.

—— (1898). L'hémistome du Martin-pêcheur. *Assoc. franc. avanc. de science, C.-R.* Paris, XXVI, 538–42.

WARD, H. B. (1901). Notes on the Parasites of the Lake Fish. III. On the structure of the copulatory organ in *Microphallus* nov. gen. *Trans. Amer. Micros. Soc.* XXII, 175–85.

—— (1917). On the structure and classification of North American Parasitic Worms. *Journ. of Parasitology*, IV, 1–12.

WEDL, C. (1857). Anatomische Beobachtungen über Trematoden. *Sitzungsber. d. k. Akad. Wissenschaft. Wien, Math.-Naturw. Cl.* XXVI, 241–78.

WESKI, O. (1900). Mitteilungen über *Distomum lancea* Dies. *Centralbl. f. Bakt.* XXVII, 579–83.

WOLFFHÜGEL, K. (1900). *Beitrag zur Kenntnis der Vogelhelminthen.* pp. 204. Freiburg-i.-Pr.

ZEDER, J. G. H. (1800). *Erster Nachtrag zur Naturgeschichte der Eingeweidewürmer.* pp. 320. Leipzig.

—— (1803). *Anleitung zur Naturgeschichte der Eingeweidewürmer.* pp. 432. Bamberg.

NOTE ON THE SECRETIONS OF THE DIGESTIVE GLANDS IN *PHTHIRUS PUBIS* L. AND THEIR BIOLOGICAL FUNCTIONS.

By FREDERICK GRÚSZ, M.D., Ph.D.

Introduction. Historical.

It is well known that the ectoparasitic Arthropods often produce in their host various skin reactions such as macules, wheals and haemorrhages, which in many cases are due to the salivary secretion of these ectoparasites. Nuttall and Strickland (1908) were the first to find an anticoagulin (called "Ixodin" by Sabbatani) in the salivary glands and alimentary canal of *Argas persicus*. Bruck (1919) found that the organs of *Culex* contained a haemolytic- and urticaria-producing substance called by him "Culicin." His study was not, however, precise, because he ground up the entire bodies of the gnats, thereby mixing up secretions, excretions and fragments of organs, some of which would never enter a wound in the process of blood sucking. Moreover, the urticaria following mosquito bite was found by Schaudinn to be due to the yeast present in the oesophageal diverticula of mosquito. Klausner (1916) states that the secretions of the salivary glands in *Cimex* are soluble in water and alcohol, are haemolytic and produce urticaria; he found also that they do not contain formic acid and that immunity to their effects is not acquired. Nuttall (1918) dealing with the effects of salivary glands of *Phthirus* on human skin states that the bluish spots of the skin are especially marked after biting of adult lice, that they have nothing to do with the blue spots in the fat body of the lice and that they are probably derived from the exuded and altered blood of man.

Personal observations.

For the study of the digestive secretions in *Phthirus pubis* I have tried, first of all, to separate the secretion of the salivary glands from that of the midgut, and the following method has been adopted for this purpose. The heads and thoraces of living lice were separated from the abdomines, each part was then separately ground up with dry quartz sand and treated with physiological saline solution, human serum and a 3 per cent. solution of sodium fluoride. The extracts were prepared in such a way that every 0·5 c.c. of solution contained the respective portions of 100 lice. Each of these two extracts was tested separately upon the washed blood corpuscles or the fresh human blood and the following results have been obtained:

(1) The extracts obtained from heads and thoraces had an anticoagulant and haemolytic property: 0·2 c.c. of this extract was sufficient to hinder the coagulation of 1 c.c. of fresh blood and in a smaller measure to dissolve the red blood corpuscles. The fluid blood slowly loses its natural colour and in six to eight weeks becomes of somewhat dark brownish hue. I did not notice, however, the formation of a special pigment. The active substance in this extract, which is derived from the salivary glands, I propose to name *Phthirolysin*.

(2) The extracts obtained from abdomines have shown, on the contrary, the existence of a coagulant and antihaemolytic substance which I propose to call *Phthiriasin*, which being more active than Phthirolysin neutralises very rapidly the action of the latter. This result explains the observation of Haase (1915) who found that, although lice when gorged, rapidly evacuate the blood, their excrements are not fluid but are always in the form of balls.

(3) The function of the salivary glands consists then in preventing the coagulation of the blood only during the process of sucking, but once the blood reaches the midgut of the louse, the action of the Phthirolysin is neutralised by Phthiriasin and the blood becomes clotted.

(4) The maculae ceruleae, as has been already shown by Nuttall, have nothing to do with the bluish spots found in the fat body of lice; they represent only imbibitional haematoidin spots which are derived from blood corpuscles destroyed by the action of Phthirolysin.

REFERENCES.

Bruck (1919). Über das gift der Stechmücken. *Deutsche Medicin. Wochenschr.*

Haase, A. (1915). *Biologie der Kleiderlause.* Berlin.

Klausner (1916). Zur Kenntnis des Wanzengiftes. *Arch. f. Dermat.*

Nuttall, G. H. F. (1918). The pathological effects of *Phthirus pubis*. *Parasitology*, x, 375–82.

Nuttall, G. H. F. and Strickland, C. (1908). On the presence of Anticoagulin in the salivary glands and intestines of *Argas persicus*. *Ibid.* i, 302–10.

THE HYDROGEN ION CONCENTRATION OF THE SOIL AND NATURAL WATERS IN RELATION TO DISEASES OTHER THAN BACTERIAL.

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Introduction.

Natural waters, lying as they do for the most part between *p*H 6·5 and *p*H 8·3 are not unfavourable to the existence of water-borne infection such as *Vibrio cholerae* and typhoid organisms. According to the results of Dernby (1921) and others the highly acid reaction of peat extracts (about *p*H 4·6) and of bog pools (at *p*H 5) would however be unfavourable to them. It appears possible also to increase the alkaline reaction of water so as to kill organisms which do not produce spores, the ever-available source of alkalis for this purpose being the mixture of potassium and sodium carbonates obtained by burning grass or other vegetation. These alkalis readily produce an intense blue coloration with thymol phthalein, denoting a reaction of *p*H 10·5 or over, whereas magnesium hydroxide does not exceed *p*H 10–10·2. Calcium hydroxide is at its limiting value at *p*H 11–12, and is known to destroy the cholera organism.

Though various pathogenic bacteria may continue to exist, if not to multiply, over a fairly wide range of reaction, yet cases are known where the activity of an organism is limited for practical purposes by a relatively slight change in *p*H value. Thus the myxomycete *Plasmodiophora brassicae*, the cause of "finger and toe" disease in turnips, does not manifest itself in soil at *p*H 7·0, though it may be destructive at *p*H 6·7.

The distribution of plants (Atkins 1922) and of many animals is limited by the *p*H value of the soil or water. Arrhenius (1921) has shown that the earthworms commonly found in cultivated land die if placed in soil beyond the limits *p*H 6–8. The writer has also found that the small crustacean *Gammarus pulex* dies in water less alkaline than about *p*H 7·4, nor does it appear to be found in streams at *p*H 6·4–6·8, though it is plentiful in Devonshire streams at about *p*H 8.

Distribution of mosquitos in relation to predominant reactions in various districts.

In connection with distribution the results obtained by MacGregor (1921) seem to be of much importance. He showed that certain species of mosquito, *Finlaya geniculata* and *Anopheles plumbeus*, which in England he had found developing in the water of tree holes, at about *p*H 4·6, were liable to be attacked by a species of the fungus *Saprolegnia* if kept in tap water at *p*H 8. On the other hand the larvae of *A. maculipennis*, *A. bifurcatus* and *Ochlerotatus nemorosus*, which breed naturally in the ponds and ditches of the region investigated at *p*H 8·2–8·4, died at *p*H 4·4, but developed normally in water as alkaline as *p*H 9·6. That the reaction of the water is not the only factor concerned has been proved by Herms and Freeborn (1920) in America. They found that *A. punctipennis* developed in certain pools with hard—and therefore alkaline—water, from which *A. quadrimaculatus* eggs were altogether absent, though the latter were found in other pools with very similar water. They noted that the eggs of the latter were far more resistant to desiccation than were those of the former. It is possible that MacGregor's work may eventually throw some light on the somewhat puzzling rarity of malaria in the neighbourhood of the Agricultural Research Institute at Pusa, in the province of Bihar, India. The water of the River Gandak, which flows through the district, is distinctly alkaline (about *p*H 8·5) and the calcareous silt of the Institute's estate and of neighbouring indigo estates is between *p*H 8 and *p*H 9. Now, though mosquitos, including, it is said, *Stegomyia fasciata*, are abundant, malaria, save in cases of persons who have contracted it elsewhere, is rare, and of mild type. No evidence of conveyance of the disease from imported cases can be obtained, though several such cases, chiefly from Assam, occurred in Pusa during the writer's recent stay there. Evidently the necessary Anopheline carrier is rare or absent. It seems not unreasonable to suggest that the carrier responsible for the disease requires an acid environment, which it is hardly able to obtain in a district so well cultivated, where dead trees are rapidly cut up for fuel and where the water of soil and river is markedly alkaline.

Lower Egypt too is remarkably free from malaria and it is noteworthy that much of the coastal region, where the main British camps were situated, has brackish alkaline subsoil water. Malaria was formerly prevalent round the fresh water canal at Ismailia but has now been stamped out. Arrhenius (1921) mentions that the good Egyptian cotton soils are at least as alkaline as *p*H 7·5 and that the country is predominantly alkaline. The researches of Joseph (1921) also show that the cotton soils of the Sudan are of marked alkalinity, *p*H 8·4–9·2.

On the other hand soil samples from tea and indigo estates in a highly malarial part of Assam were all found by the writer to be acid, from *p*H 5·4 to *p*H 6·2. The greatly higher rainfall in Assam and the fact that the jungle

here affords many lodging places for water, in which an acid reaction would be produced by decaying vegetation would appear to be material in considering the difference in the incidence of malaria in the two provinces.

Instructions for keeping malaria in check specifically mention old tin cans and jars as likely breeding places. Rain-water collected in even a clean jar may be close to *p*H 6 through the absorption of carbon dioxide and the rusting of tinned cans further gives rise to an acid solution, since ferrous salts give an acid reaction and ferric salts are still more acid. Distilled water after lying in a well cleaned tinned can was observed to be at *p*H 5·4 when rust had developed. Thus there appears to be a certain amount of indirect evidence connecting the prevalence of malaria with the existence of acid water for the development of the larvae of certain species. The existence of an alkaline soil will not of course give rise to alkaline water in the holes of trees, but it is possible that the acidity may be less pronounced than in plants grown on soils of an acid character.

It is however known that *A. maculipennis* and *A. bifurcatus*, breeders in alkaline water, can transmit malaria. Furthermore Carter and Blacklock (1922) have infected *A. plumbeus* (*A. nigripes*) experimentally and consider it as a potential carrier of malaria in England. This is an exclusively sylvan species, and is widely distributed wherever beech, sycamore, chestnut or other trees with water-containing rot holes are to be found. This distribution is in agreement with MacGregor's results obtained by rearing the larvae in acid water.

The fact that certain known transmitters are thus able to develop in alkaline water does not support the hypothesis concerning the distribution of malaria that has been advanced tentatively here, but it is possible nevertheless that the reaction, the salinity and perhaps in an indirect manner the oxygen content of the water may each contribute something in regulating the distribution of mosquitos[1].

Distribution of snail hosts of Trematodes in relation to regional reaction.

That the distribution of snails as well as of mosquitos is influenced by the reaction of the soil and water, is becoming clear from the work carried out by Miss M. V. Lebour and the writer (1923). Thus it has been observed that in Devon *Helicella caperata* and *H. virgata* occur in abundance on banks where the soil is at about *p*H 8. Some other species are most abundant at about *p*H 7, and highly acid peaty regions and acid soil over quartzite are remarkably devoid of snails. Those that are found in acid regions have hyaline shells, though such shells are also found in calcareous regions. The calcareous shell is however confined to the alkaline calcareous localities.

[1] In this connection the work of Barney and Anson (1920) which correlates the abundant development of the top minnow, *Gambusia affinis*, with the high oxygen content of the pond water is to be noted.

Since many trematodes infect snails, producing diseases in their final hosts, it is of interest to review recent work on Trematodes on the hypothesis that their distribution depends on the hydrogen ion concentration of the soil and water as limiting the distribution of their hosts, the snails, and as affecting the liberated miracidia.

The very general occurrence of the one or more species which carry *Schistosomum haematobium* and *S. mansoni* in Egypt is probably connected with the alkaline character of the water.

Similarly the distribution of the snail *Physopsis africana* which has been found in brickfields at Durban and in other places may be limited by the soil reaction. Cawston (1917) has stated that this is the intermediate host concerned in bilharziosis in S. Africa. The occurrence of *P. africana* on the leaves of water-lilies noted by Cawston (1922) indicates an alkaline habitat since most water-lilies require one.

Again a definite relation has been shown to exist between a skin disease "kabure" in Japan and infection with *Schistosomum japonicum*. According to Narabayashi (1917) the Trematode is carried by a small snail *Blanfordia nosophora*, Robson, found in rice fields. Since rice grows well in calcareous soils it is probable that the habitat is alkaline.

The ravages caused by liver fluke in sheep and cattle, due to *Fasciola* (*Distomum*) *hepatica*, are well known. The distribution of the snails concerned, *Limnaea truncatula* and *L. peregra* (Taylor 1922) in relation to soil reaction is of interest and requires careful investigation. In parts of Ireland fluke does not occur on mountain lands where heather and bracken are plentiful. Such localities are always acid—from *p*H 4·6 for peat to *p*H 5·4 or thereabouts. But it is also known to occur on poor wet pastures at lower levels, which are usually somewhat acid, roughly about *p*H 6. So far it has been found possible to examine a single habitat only, which was at *p*H 7.

The cercariae of the Bitter Root Valley, Montana, U.S.A., have recently been studied by Faust (1917) who found thirteen species, though a search along the river for fifty miles proved that the gasteropod fauna consists of three species only, *Limnaea proxima* Lea, *Physa gyrina* Say., and *Planorbis trivolvis* Say. Contour maps show that this river rises at about 6000 ft. in the Bitter Root Mts. and falls rapidly to 3000 to 4000 ft., so that it probably contains acid upland water. The poverty in species of snails also suggests acid water, for it has been ascertained recently that the number of species of snails, like that of other animals and plants, is greatest in the region of neutrality or slight alkalinity.

Of these three Montana snails *P. trivolvis* has been found by Magath (1918) to be the host of a trematode *Lissorchis fairporti* Magath, which was responsible for a large death rate among buffalo fish, *Ictiobus bubulus* and *I. cyprinella* in fish ponds at Fairport, Iowa. The cercariae spend the winter in the liver of the snail, and fish are not infected directly either by feeding or injection but only through a Chironomid larva. The remedy suggested was protection

of the ponds from *P. trivolvis*. Magath observed that this snail was very common around the ponds, but did not seem to be found in the river, the Mississippi. He remarks "this species of snail is common in some rivers and no explanation can be offered as to why it is not found around Fairport." Three other snails are recorded as being present with *P. trivolvis*, but free from the cercariae of *L. fairporti*. The three do not include either of the species associated with *P. trivolvis* in the Bitter Root Valley. Now the Mississippi near Fairport according to the analysis recorded in Clarke's *Data of Geochemistry* contains calcium salts sufficient to bring the water to the neighbourhood of *p*H 8. It therefore seems possible that *P. trivolvis* can endure the upland—probably acid—water of the Bitter Root River and the probably less acid or slightly alkaline conditions of the Fairport ponds, but not the strongly alkaline water of the Mississippi. Its associates however may be limited firstly by the hydrogen ion concentration being too low for the Bitter Root species to occur with it in the Fairport ponds, and secondly by the concentration being too high for the Fairport species to occur in the Bitter Root River.

Species of river snail of the genus *Melania* are concerned in the transmission of the human lung Distome, *Paragonimus westermani* as shown by Nakagawa (1919). His earlier researches had traced human infection to two species of fresh water crab which are eaten by the aboriginal villagers in the Shinchiku district of Formosa. Out of seventeen species of cercariae examined, only one was found in the district most highly infected. This seems to be a limitation in distribution so striking as to indicate some clear cut difference in the nature of the water of the district. In Japan Yoshida (1915) has reported infection in three species of fresh water crab, indicating a wider range.

Summary.

Certain facts are known concerning the correlation of the distribution of animal species and the hydrogen ion concentration of the soil and water. An attempt is made to apply them to the distribution of malarial fever, as illustrating insect borne disease, and to some of the numerous Trematode infections, afflicting man and other animals, in which snails act as intermediate hosts. The importance of measurements of hydrogen ion concentration (by the colorimetric method) by field workers on the distribution of animals is urged.

The writer wishes to acknowledge his indebtedness to Dr M. V. Lebour for the suggestion that snails may prove a suitable group for the study of the relation between the reaction of the habitat and animal distribution.

BIBLIOGRAPHY.

Arrhenius, O. (1921). The hydrogen ion concentration of Egyptian soils and the reclamation of alkaline land. *The Cairo Scientific Journal*, x, Nos. 104 and 105.

—— (1921). Influence of soil reaction on earthworms. *Ecology*, II, 255–7.

ATKINS, W. R. G. (1922). Some factors affecting the hydrogen ion concentration of the soil and its relation to plant distribution. *Scientific Proceedings of the Royal Dublin Society*, XVI, 369–413.

—— (1922). Note on the occurrence of the Finger and Toe disease of turnips in relation to the hydrogen ion concentration of the soil. *Loc. cit.* 427–8.

ATKINS, W. R. G. and LEBOUR, M. V. (1923). Soil reaction, water snails and liver flukes. *Nature*, CXI, 83.

BARNEY, R. L. and ANSON, B. J. (1920). Relation of certain aquatic plants to oxygen supply and to capacity of small ponds to support the Top minnow (*Gambusia affinis*). *Transactions of the American Fisheries Society*, pp. 268–78.

CARTER and BLACKLOCK (1922). Cited from note in *Nature*, CX, 526.

CAWSTON, F. G. (1917). The cercariae of Natal. *Parasitology*, III, 131–5.

—— (1922). The occurrence of *Physopsis africana* in Natal. *British Medical Journal*, June 17.

CLARKE, F. W. (1920). Data of Geochemistry. *U.S. Geological Survey, Bulletin* 695. Washington.

DERNBY, K. G. (1921). La concentration optima en ions hydrogène favorisant le développement de certains microorganismes. *Annales de l'Institut Pasteur*, XXXV, 277–90.

FAUST, E. C. (1918). Studies on Illinois cercariae. *Parasitology*, IV, 93–110.

HERMS, W. B. and FREEBORN, S. B. (1920). The egg-laying habits of Californian Anophelines. *Ibid.* VII, 69–79.

JOSEPH, A. F. (1921). The hydrogen ion concentration of cotton soils. *Report of the Government Chemist, Sudan*, Khartoum, pp. 26, 27.

MACGREGOR, M. E. (1921). The influence of the hydrogen ion concentration on the development of mosquito larvae. *Parasitology*, XIII, 348–51.

MAGATH, T. B. (1918). The morphology and life-history of a new Trematode parasite, *Lissorchis fairporti* nov. gen., et nov. spec. from the Buffalo Fish, *Ictiobus bubulus*. *Ibid.* IV, 58–69.

NAKAGAWA, K. (1919). Further notes on the study of the human lung Distome, *Paragonimus westermani*. *Ibid.* VI, 39–43.

NARABAYASHI (1917). Note signed H. B. W. *Ibid.* III, 182.

TAYLOR, M. (1922). Water snails and liver flukes. *Nature*, CX, 701.

YOSHIDA, S. (1915). On the intermediate hosts of the lung distome, *Paragonimus westermani* Kerbert. *Parasitology*, II, 111–18.

A NEW STRUCTURE IN THE FLAGELLATE, *PSEUDOTRICHONYMPHA SPHAEROPHORA* SP.N.

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(With Plate VI.)

Mr J. F. M. Floyd was good enough to hand over to me for report some smears which he had made in British Guiana from the contents of Termite intestines. Prof. Silvestri, who was kind enough to examine some Termites taken from the same colony as those which furnished the material for the smears, identifies them as belonging to the species, *Rhinotermes nasutus* Perthy, and it is probable that this is the host of the parasite described below.

The smears had been fixed in corrosive-acetic mixture and preserved in 70 per cent. alcohol. I stained some of them in Dobell's iron-haematein and others in Jansen's picro-carmine, a stain very suitable for large organisms like Trichonymphs with nuclei rich in chromatin.

The Trichonymphs are numerous in one or two of the smears, and belong to the genus *Pseudotrichonympha*, agreeing with Grassi's (1911) and Koidzumi's (1921) descriptions. The natural shape is doubtful, owing to the contortions produced by the fixative, but is probably a long oval (Pl. VI, fig. 2), in size 230μ by about 65μ. The organ called the "nipple" by Koidzumi (1921) and centroblepharoblast by Kofoid and Swezy (1919) is very prominent, and agrees with Koidzumi's account (*loc. cit.*), except that the formation which he describes as a button at the distal end of the tube appears to me more like a clear space in the terminal portion of the "nipple" (Pl. VI, figs. 3 and 4).

As no dividing specimen was seen I am unable to describe the behaviour of this centroblepharoblast during nuclear division.

The structure to which I wish to draw attention however, is a dark body, made up of one or more spheres, present in every specimen of this *Pseudotrichonympha* examined by me (see Pl. VI, fig. 1). This body consists of a dark solid non-staining centre covered by a layer which is lighter in colour and roughly concentric in structure. Small black bodies and specks are distributed in this outer layer (Pl. VI, figs. 5–7). The constant presence of this body points to its being of some physiological importance, and it may be suggested that it functions as stercoma for the storing up of solid faecal and excretory material, largely the undigested remains of the woody fibres which can be seen in the body of the creature and which apparently form its food.

It would be impossible to miss seeing this structure in a Trichonymph, for it is as prominent a structure as the nucleus. One can only suppose therefore that it is absent from the other described species of Trichonymphs. It is to be hoped that others with better opportunities for studying this group may be able to ascertain its nature and function in the living organism.

This peculiar and constant character of the species under description make it necessary to assign to it provisionally a new specific name in spite of our scanty knowledge regarding it, and I suggest the name

Pseudotrichonympha sphaerophora sp.n.

Description: Oval form 230μ × 65μ with characters of genus—see Grassi (1917) and Koidzumi (1921)—with additional specific character of a brown non-staining sphere or spheres as large as the nucleus (25μ diam.). Host: probably *Rhinotermes nasutus* Perthy from British Guiana.

REFERENCES.

Dobell, C. (1910). *Spolia Zeylanica*, VII, 65.
Grassi, B. (1917). *Mem. della R. Accad. dei Lincei*, Ser. 5, XII, 331.
Grassi, B. and Foa, A. (1911). *Atti della R. Accad. dei Lincei*, Ser. 5. Rendiconti XX, 725.
Janicki, C. (1915). *Zeitschr. f. wissensch. Zool.* CXII, 573.
Kofoid, C. A. and Swezy, O. (1919). *Univ. Calif. Publ. Zool.* XX, 41 and 99.
Koidzumi, M. (1921). *Parasitology*, XIII, 235.

EXPLANATION OF PLATE VI.

All figures were drawn with the aid of an Abbe drawing apparatus, and have been carefully copied for reproduction by Miss M. Cameron. I have to thank the Carnegie Trustees for a grant in aid of the expense of illustration.

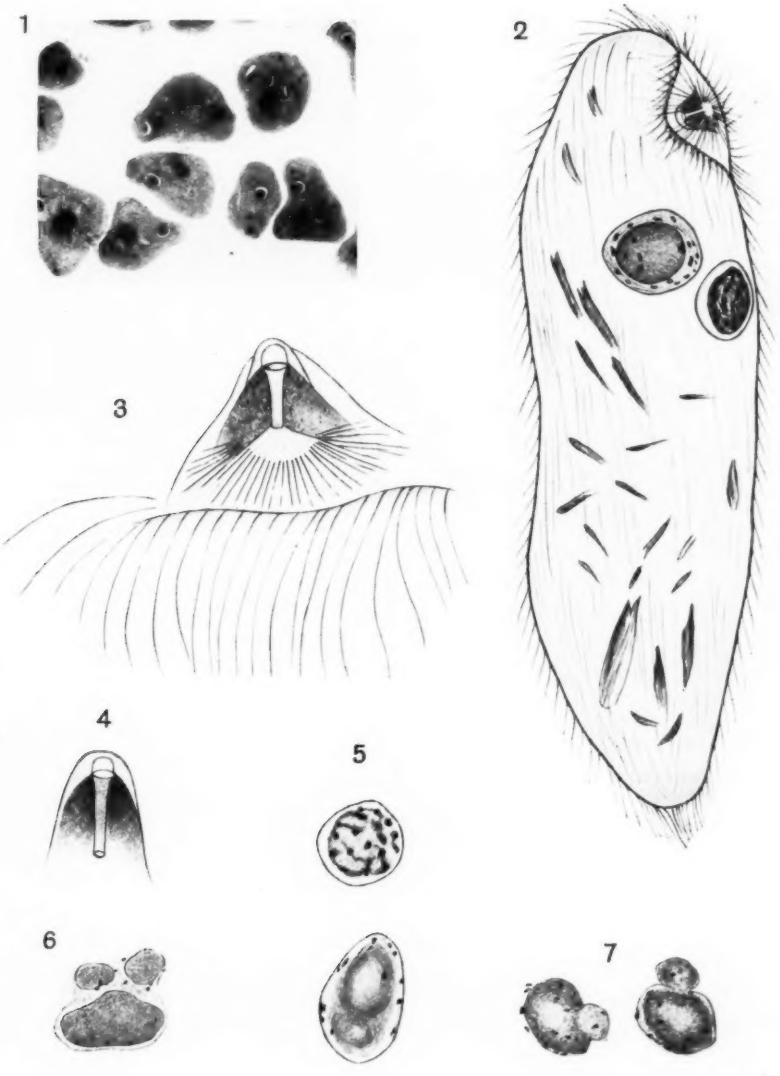
Fig. 1. Photograph of *Pseudotrichonympha sphaerophora* sp.n. in smear of gut of *Rhinotermes nasutus*. Each individual shows the clear nucleus and the duller spherical (stercoma?) body of about the same size. ×125.

Fig. 2. *P. sphaerophora* showing nucleus, food material consisting of woody fibres, stercoma-like body, centroblepharoblast and ciliation of body. ×500.

Figs. 3 and 4. Different examples of the centroblepharoblast. ×1250.

Fig. 5. Nucleus with spherical body below for comparison. ×1250.

Figs. 6 and 7. Different forms of the spherical body (stercoma?). ×1250.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OBSERVATIONS ON HUMAN INTESTINAL PROTOZOA IN MALAYA.

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(With Plate VII and 14 Text-figs.)

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Incidence of Infection.

During the year April 1921–April 1922 I examined the stools of 1034 men from the dysentery ward of the District Hospital, Kuala Lumpur, in the Federated Malay States. In this hospital the patients are for the most part indigent Chinese and Tamils of the coolie class, who have resided in Malaya for a length of time varying from a few weeks to a number of years, sometimes all their lives. From the way in which these people live, from the intimate mixture of so many different nationalities, and from their often extensive migrations, one might be led to expect that their intestinal fauna would be abundant both in variety of species and in incidence of infection. This expectation is not realised in the following results. Indeed, the figures for some of the non-pathogenic protozoa are not as high as some which have been obtained for healthy Englishmen who have never left England (cf. Matthews and Malins Smith, 1919). Nearly all the patients in this series were suffering, or had recently suffered, from active dysentery at the time when the examinations were made: and in some cases the flushing out of the intestine from this cause probably reduced the intestinal protozoa to such small numbers that none could be found when specimens of the stools were examined. In many cases, also, protozoa have certainly been overlooked in the masses of pus and other cells present in a very large proportion of the stools examined. Had it been possible to examine a series of cases without intestinal derangements involving diarrhoea from the same population, some opinion might have been formed as to the actual effect of these two factors on the results

obtained. And until some such figures are available for comparison it cannot be said that the scarcity of some of the intestinal protozoa found in these cases has any special significance.

It was intended to examine each patient thrice, and only a very small proportion had fewer than three examinations while a few, particularly amongst those infected with *Entamoeba histolytica* who received emetine treatment, had more.

Sometimes amoebae were seen which were undoubtedly either *E. histolytica* or *E. coli*, but which it was found impossible to allocate to either species with certainty owing to their being either present in very small numbers, or too much degenerated for diagnosis. Degeneration of free organisms, as of tissue cells, is very rapid at the temperatures (25–30° C.) experienced daily in the laboratory; for example it was found to be of little use to examine stools in the afternoon which had been brought to the laboratory in the morning of the same day. In patients where only such doubtful amoebae were seen at all examinations they are shown as "? Amoebae" in the table. They probably represent a mixture of *E. histolytica* and *E. coli* in approximately equal proportions.

Table I.

Intestinal protozoa in 1034 *cases.*

Organism	No. of cases	% of 1034 cases
Entamoeba histolytica	150	14·5
E. coli	80	7·7
? Amoebae	26	2·5
Endolimax nana	23	2·2
Iodamoeba bütschlii	4	0·4
Giardia intestinalis	43	4·2
Trichomonas hominis	119	11·5
Chilomastix mesnili	26	2·5
Enteromonas hominis	36	3·5
Embadomonas intestinalis	1	0·1

It is interesting to observe that the organisms found in the most surprisingly low numbers are the three non-pathogenic amoebae shown in the table; these three organisms are undoubtedly those most easily overlooked amongst a collection of tissue cells: whilst an organism like *Trichomonas*, which is rendered easily visible by its active movements, shows a comparatively high incidence.

In the *Report* of the Uncinariasis Commission to the Orient, 1915–1917 (pp. 112–13), it is stated of the coolie population of Kuala Lumpur that "the Chinese as a race are more vigorous and resistant to disease than are the Tamils." As there pointed out this is probably due to some extent at any rate to the better conditions under which the former live. In the present series of cases also, when the Chinese and the Indians are placed in separate groups, there is a marked and consistent difference in the degree of infection with both pathogenic and non-pathogenic intestinal protozoa as shown in Table IV. The degree of infection is far higher among the Indians, a fact

which may be correlated with their poorer mode of life as compared with the Chinese.

Table II.

Incidence of intestinal protozoa in relation to nationality.

Organism	674 Indians (mostly Tamils) No.	%	356 Chinese No.	%	4 Malays No.
Entamoeba histolytica	129	19·1	20	5·6	1
E. coli	74	11·0	6	1·7	—
? Amoebae	21	3·1	5	1·4	—
Endolimax nana	19	2·8	4	1·1	—
Iodamoeba bütschlii	4	—	0	—	—
Giardia intestinalis	34	5·0	9	2·5	—
Trichomonas hominis	111	16·5	8	2·2	—
Chilomastix mesnili	24	3·6	2	—	—
Enteromonas hominis	33	4·9	3	—	—
Embadomonas intestinalis	0	—	1	—	—

Entamoeba histolytica.

Of the 150 patients infected with *E. histolytica*, cysts were found in 27 cases only:

20 cases produced only cysts over 10 μ in diameter.

5 cases produced only cysts under 10 μ in diameter.

2 cases produced cysts both over 10 μ and under 10 μ in diameter.

One case (No. 1473) was suffering from acute amoebic dysentery when first examined, passing typical blood and mucus stools containing tissue-invading amoebae; after treatment his stools were faecal, and on the fifth day after the end of his course showed numerous cysts of *E. histolytica*, 6·0–7·5 μ in diameter. This case is interesting as a further indication that the tissue-invading stage of a small cyst-forming strain of *E. histolytica* differs morphologically only slightly, if at all, from that of the large cyst-forming strains, for no peculiarity, *e.g.* a difference in size, had been noted in the amoebae originally present in the stools (cf. Dobell, 1919, p. 55).

In this series of cases there were 14 who, at the time of examination, showed no signs of dysentery in their stools. Of these 14 cases

8 produced only cysts over 10 μ in diameter.

4 produced only cysts under 10 μ in diameter.

2 produced cysts both above and below 10 μ in diameter.

That is to say, in the patients with no signs of dysentery the proportion of small-cyst-forming infections to large-cyst-forming infections is 1 : 2; whereas in the whole number of patients it is only 1 : 4. If we classify the patients according to the dimensions of the cysts which they passed we have the result shown in Table II.

Table III.

Diameter of cysts	No. of patients	Dysentery (according to stool) Acute	Slight symptoms	No symptoms
Over 10 μ only	20	9	3	8
Under 10 μ only	5	1	0	4
Both over and under 10 μ	2	0	0	2

That is to say, of the cases producing cysts over 10μ in diameter, there were twelve with dysenteric stools to ten with non-dysenteric stools; while of the cases producing only cysts under 10μ in diameter, there was only one with dysenteric stools to four with non-dysenteric stools. May these facts be considered as an indication of a lesser tendency to produce acute symptoms in strains of *E. histolytica* forming small cysts than in those strains which form cysts of a larger size? (cf. Jepps, 1921, p. 7)[1].

Trichomonas hominis.

From time to time there have appeared publications dealing with the possible pathogenicity of intestinal flagellates, and of late *T. hominis* has received a large share of attention in this connexion (see Wenyon, 1920, for the salient points of recent work). In the present series of examinations this flagellate was found in stools containing red blood cells on 94 occasions, and in 11 (or 11·6 per cent.) of these some of the *Trichomonas* contained ingested erythrocytes; no ingestion of red blood cells was ever observed on the slide. The only other human intestinal protozoon observed to be in the habit of ingesting red blood corpuscles is the pathogenic *E. histolytica*; but we cannot on this account alone ascribe any definitely pathogenic activity to *Trichomonas*. No evidence has so far been obtained of any ulceration due to this organism. Ingested erythrocytes were never seen more than once in the same patient in spite of the fact that they were present in the stool with the flagellates on two different occasions in thirteen patients, on three occasions in four patients, and on four occasions in two patients which suggests first, that they were not an essential feature of the intestinal condition; and secondly, that the *Trichomonas* ingesting red blood cells is not a different organism from the more usual form with no ingested erythrocytes.

The relatively frequent detection of *Trichomonas* in this series of cases almost all of whom exhibited some degree of diarrhoea at the time of their examination is interesting, not as any evidence of pathogenicity but as an indication that the flagellate may occur much more commonly than has been supposed, at any rate in certain classes of patient. It is to be expected that this organism which, so far as one knows, forms no cysts in its human host will not be discovered unless there is a diarrhoeic condition of the intestine; and this point must be borne in mind when estimating its incidence as compared with other organisms which may be detected in the cystic condition (cf. Dobell, 1922. *Chilomastix mesnili* "is one of the commonest flagellates of man;...*Trichomonas*—which is far less common....").

[1] It may be objected that these numbers are small; and that it would be much easier to miss cysts of a smaller size in examining the stool, particularly when cellular débris is plentiful. It does not, however, seem very probable that the second factor has had much influence on the comparative results given above, since cysts are in any case rarely present with much cellular débris. Of the 34 stools in which large cysts were seen only one was not faecal, or had a high cellular content.

Embadomonas intestinalis. (Pl. VII, figs. 1–8.)

This small flagellate was first described from the human intestine under the name of *Waskia intestinalis* by Wenyon and O'Connor (1917). Since then its occurrence in America has been reported by Kofoid, Kornhauser, and Plate (1919) who found it in four out of 300 home-service soldiers, and by Hogue (1921). Alcock and Thomson (1922) found it in England in a patient who had resided in the East for many years. By the present series Malaya is added to the list of places where it is known to occur. Only one infected case is shown in Table I, but it is almost certain that at least one other was observed about three months earlier; unfortunately the parasite was not identified at the time, nor studied in sufficient detail for certain identification at a later date.

Although several descriptions of *Embadomonas* have recently appeared, it does not seem superfluous to record some of the present author's observations on this comparatively unknown parasite, and to give a few sketches of living and of stained specimens for comparison with those of the earlier publications. The living flagellate is very active, but its peculiar cytostome with a single stout flagellum gives it a very characteristic form, which has been compared to that of a slipper or of a little bird. Some of the broader individuals resemble in outline a fish with widely open mouth particularly if the nucleus be indistinctly visible, as it is in some specimens (*e.g.* Pl. VII, fig. 1).

References have been made by previous authors to its voracious appetite—a constant stream of bacilli, cocci, etc. may sometimes be seen to pass in at the cytostome under the influence of the lashing cytostomal flagellum. Plate VII, fig. 4, depicts an individual with a bacillus protruding from its hinder end. This is not an occurrence frequently observed but bacilli have also been seen in stained preparations projecting through the cytoplasm at other points of the organism. Whether this is a normal process which occurs during life, or an artefact produced by shrinkage of the protoplasm during preparation, it is impossible at present to decide. With regard to the actual structure of the organism it is only necessary here to refer to the figures, as there are no new particulars to add to previous descriptions, and no differences to note. The cysts are minute white objects, very opaque and showing no internal structure when fresh. They may be distinguished from the similarly shaped cysts of *Chilomastix mesnili* by their usually smaller size, and the absence of the shining grains of volutin characteristic of that species. In iodine solution slight indications of the nucleus and the cytostomal loop sometimes appear; and some cysts are seen to contain diffuse glycogen. It is not easy to make out the cyst contents in stained preparations; with iron-haematoxylin their differentiation is very unsatisfactory and a long search is sometimes necessary before a cyst is found which shows any internal details at all. For this reason the cysts of *Embadomonas* have proved a puzzle, and there have been widely differing accounts of their structure. A careful study of the preparations

made from the present case has shown that, whenever their contents are visible the cysts appear to be uninucleate, and contain besides a deeply staining sling-like structure which probably represents the cytostome border of the free flagellate. This is also their structure as finally described by Dobell and O'Connor, 1921, p. 79.

Embadomonas appears to be a truly parasitic inhabitant of the intestine and it will not survive for very many hours outside the body of its host. On three occasions (once from the earlier and twice from the later case) stools which, when fresh, contained large numbers of free flagellates were kept over-night: no flagellates survived till the following morning; but cysts, when they were present, remained apparently unchanged. Attempts at cultivation on ordinary laboratory media all failed (cf. however, Hogue 1921, who gives an account of successful cultures of *Embadomonas* on special media).

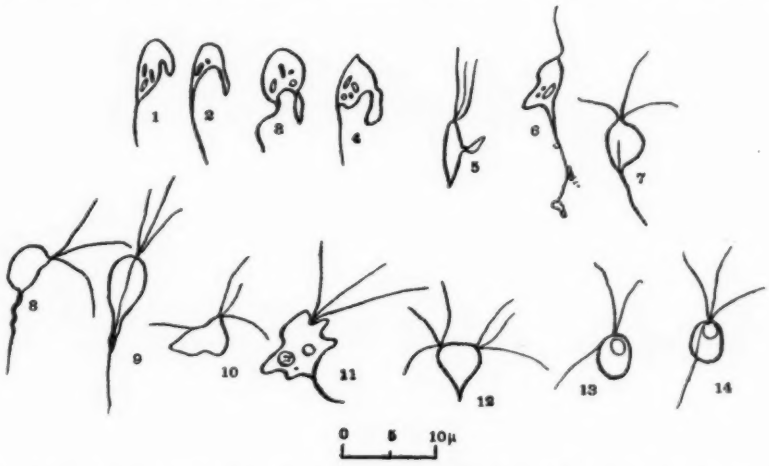
Enteromonas hominis. (Pl. VII, figs. 9–13.)

Under this name is reported a small flagellate from 3·5 per cent. of the cases in this series, which is undoubtedly that redescribed as *Tricercomonas intestinalis* by Wenyon and O'Connor (1917), and of which Dobell (1922) wrote: "The organism appears to be very uncommon, and has hitherto only been found in persons in or from the near East." The same flagellate was found in one military case at Southampton (Jepps, 1921).

Dobell (Dobell and O'Connor, 1921) has discussed in full the various small flagellates described by several authors as inhabiting the human intestine, and concludes that this same organism has been often redescribed and under many different names, sometimes receiving as many as three distinct names from one author (for bibliography see Dobell and O'Connor, 1921). A comparison of the illustrations given by all these authors with the living forms and the permanent preparations obtained from the present series of cases tends to support his opinion. It is, as Dobell says, not possible to be certain, for many of the descriptions are incomplete, and some of the illustrations are almost useless from this point of view. However, the flagellate is exceedingly difficult to study on account of its small size, its extraordinary activity during life, and the fact that very good preparations of fixed and stained specimens are rarely obtained. Its very amoeboid constitution, and the considerable deformation it often undergoes, rendering it impossible to make out the insertion of its four long flagella during life, are added difficulties. These considerations may suffice to account for the great diversity in the descriptions of the various organisms at present to be included under the one name *E. hominis* da Fonseca 1915.

Text-figs. 1–11 are sketches from living flagellates, and give some idea of the everchanging form of the organism. There are three free flagella at the anterior end of the body, and a fourth which is adherent to the body for a longer or shorter distance, but it is not always possible to make out all four flagella in one specimen: ingested food particles are usually abundant, although

there appears to be no definite cytostome. Text-figs. 12 to 14 illustrate some flagellates seen in iodine solution, which sometimes renders the nucleus visible; and Pl. VII, figs. 9–13, represent fixed and stained specimens showing the nucleus, and the origin of the flagella in a small group of blepharoplasts on its anterior margin. The structure of the nucleus is exceedingly difficult to determine. Fixation and differentiation are often very unsatisfactory—as would appear to be the general experience, judging from the figures and descriptions given by most of the authors who have dealt with this organism. When the nuclear structure is recognisable in these the karyosome is given different dimensions by different authors, but nearly always larger than it appears to have as a



Figs. 1–11. *Enteromonas hominis*. Sketched from living flagellates. Figs. 1–5 illustrate a very common deformation by the protrusion of a finger-like lobe of protoplasm which often persists for a very long time. In Fig. 6 are shown particles of débris attached to the trailing flagellum.
Figs. 12–14. From flagellates in Weigert's iodine solution. Fig. 12 probably represents a dividing organism.

rule in my preparations: but some of the previous figures showing the largest karyosomes suggest that the structure so called really represents the whole nucleus, which has not been sufficiently differentiated.

No cysts were ever observed in any of the cases in the present series. Wenyon and O'Connor (1917) described cysts from only one of their cases, and similar cyst-like bodies were present in the formed stools obtained from the Southampton case infected with *Enteromonas* (= *Tricercomonas*). None of the other organisms described under different names but provisionally included in this genus have been associated with any kind of cystic stage however, and further evidence on this point is very desirable.

E. hominis is a true parasite of the human intestine. It will survive for a few hours only outside the body. Stools containing flagellates from fifteen

different patients were kept overnight, and in only one case were there any alive on the following morning; these all died during the day. Stools were kept from two of these fifteen patients on two occasions each: in one case no flagellate survived overnight at either time, and in the other a few survived on both occasions. In one stool *Trichomonas* survived after all the *Enteromonas* had died. All attempts to cultivate the flagellate on ordinary laboratory media failed.

REFERENCES.

Broughton-Alcock, W. and Thomson, J. G. (1922). *Embadomonas intestinalis* (Wenyon and O'Connor) 1917: description of the cysts and free forms found in a case in England. *Proc. Roy. Soc. Med.* xv, 4, Section of Tropical Diseases, &c., p. 8.

Darling, S. T., Barber, Marshall, A. and Hacker, H. P. (1920). Hookworm and Malaria research in Malaya, Java, and the Fiji Islands. *Report of the Uncinariasis Commission to the Orient*, 1915–1917, *Rockfeller Foundation.*

Dobell, C. (1919). *The amoebae living in man.*

—— (1922), in the *Practice of Medicine in the Tropics*, ed. Byam and Archibald, II, 1495.

Dobell, C. and O'Connor, F. W. (1921). *The intestinal protozoa of man.*

Hogue, M. J. (1921). *Waskia intestinalis:* its cultivation and cyst formation. *Journ. Amer. Med. Assoc.* lxxvii, 112.

Jepps, M. W. (1921). Notes on the intestinal protozoa of 971 men at the University War Hospital, Southampton. *Journ. Roy. Army Med. Corps*, xxxvii, 366.

Kofoid, C. A., Kornhauser, S. I. and Plate, J. T. (1919). Intestinal parasites in overseas and home service troops of the U.S. Army. *Journ. Amer. Med. Assoc.* lxxii, 1921.

Matthews, J. R. and Malins Smith, A. (1919). The spread and incidence of intestinal protozoal infection in the population of Great Britain. *Ann. Trop. Med. and Parasitol.* xiii, i. 91.

Wenyon, C. M. (1921). Histological observations on the possible pathogenicity of *Trichomonas intestinalis*, etc. *Journ. Trop. Med. and Hyg.* xxiii, 125.

—— (1921). Cultivation of *Embadomonas. Trans. Roy. Soc. Trop. Med. and Hyg.* xv, 5 and 6, 154.

Wenyon, C. M. and O'Connor, F. W. (1917). An enquiry into some problems affecting the spread and incidence of intestinal protozoal infections of British troops and natives in Egypt, etc. *Journ. Roy. Army Med. Corps*, xxviii, 358.

EXPLANATION OF PLATE VII.

All permanent preparations are fixed in sublimate-acetic-alcohol and stained with Heidenhain's iron haematoxylin.

Figs. 1–8. *Embadomonas intestinalis.*

Figs. 1–3. Two flagellates and a cyst from living specimens.

Figs. 4–6. Flagellates from fixed and stained preparations. Fig. 6 represents a stage in the process of division.

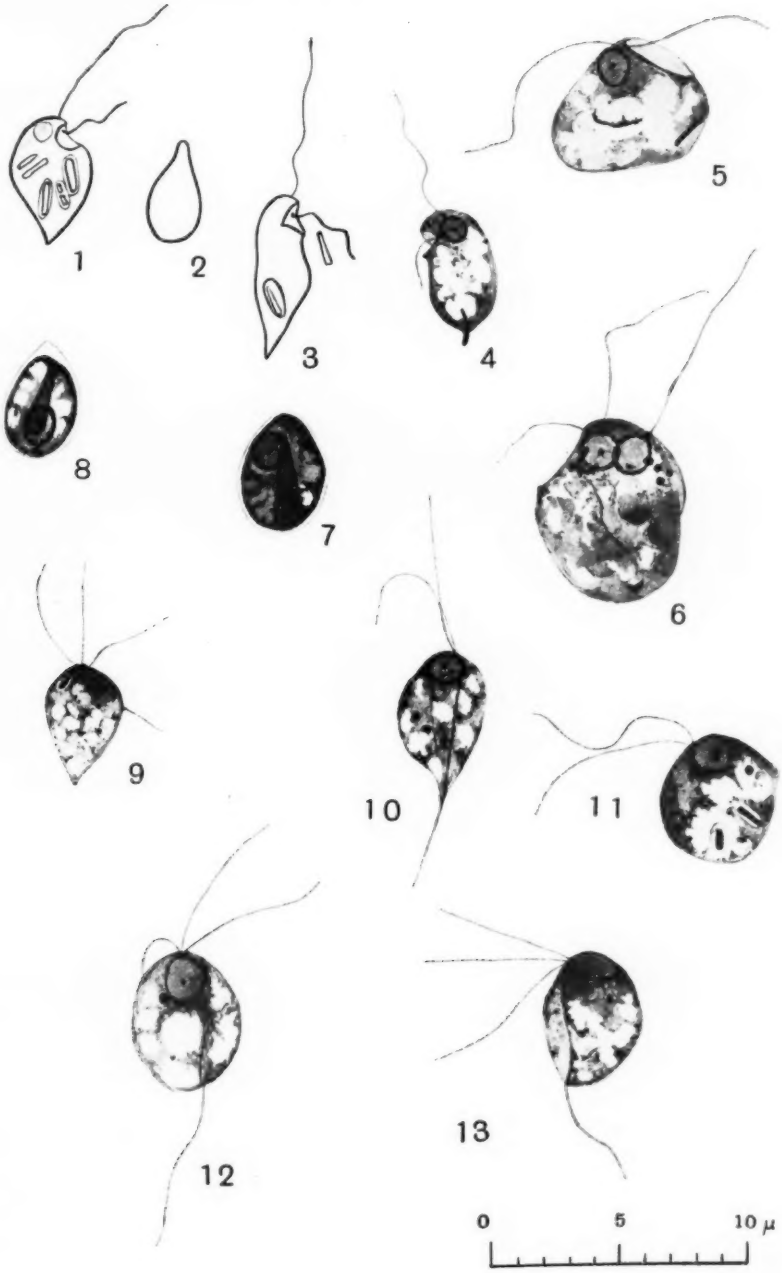
Figs. 7–8. Cysts from fixed and stained specimens.

Figs. 9–13. *Enteromonas hominis.*

Flagellates from fixed and stained preparations. Fig. 12 from a preparation counterstained with eosin.

In Figs. 10 and 11 only three and two flagella respectively are visible.

Fig. 13 shows the grooved appearance along the course of the recurrent flagellum described by Wenyon and O'Connor (1917).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NOTE ON GEOFFREY WATKINS SMITH, WHOSE PORTRAIT APPEARS IN *PARASITOLOGY*, XV, No. 2.

Portrait-plate XXIV.

(Continued from p. 112.)

By F. A. POTTS, M.A.

Geoffrey Watkins Smith, M.C., M.A. (Oxon.) was born 9 Dec. 1881 at Ivy Bank, Beckenham, Kent and was killed on the Somme, in July, 1916, at the early age of 34. He was Fellow and Tutor of New College and Lecturer in the Department of Zoology and Comparative Anatomy at Oxford. His published work covers a period of only eleven years but it is remarkable in quantity and quality alike and shows forth its author as one who would have achieved the foremost rank among English biologists.

To some he is best known for his three years of happy residence at Naples and enthusiastic work at the Stazione Zoologica where he completed the only monograph in the *Fauna und Flora des Golfes Neapels* written by an Englishman. This was on the group of parasitic Cirripedes known as the Rhizocephala. Delage's classic paper on "L'Evolution de la Sacculine" was published in 1884 but in the early days of this century it still remained unconfirmed, and when Smith undertook the monograph at the invitation of Anton Dohrn it was expected by many of the workers at Naples that he would contradict the amazing story which Delage had told. It was originally supposed by Kossmann and others that the Cypris larva fixed upon the abdomen of the crab and became transformed *in situ* into the adult animal. When the discovery of a transitional wholly internal stage was announced by Delage the simpler explanation continued to recommend itself to some and particularly to another eminent French zoologist, Giard. In the course of the controversy which ensued, Giard made his valuable observations on the phenomenon which he termed "La Castration Parasitaire." At the end of three years' work on the Rhizocephala, Smith had been forced to conclude that Delage was perfectly correct in his main outline of the life-history of *Sacculina*. He had also in Giard's "Castration Parasitaire" found the subject from which nearly all his future work sprang.

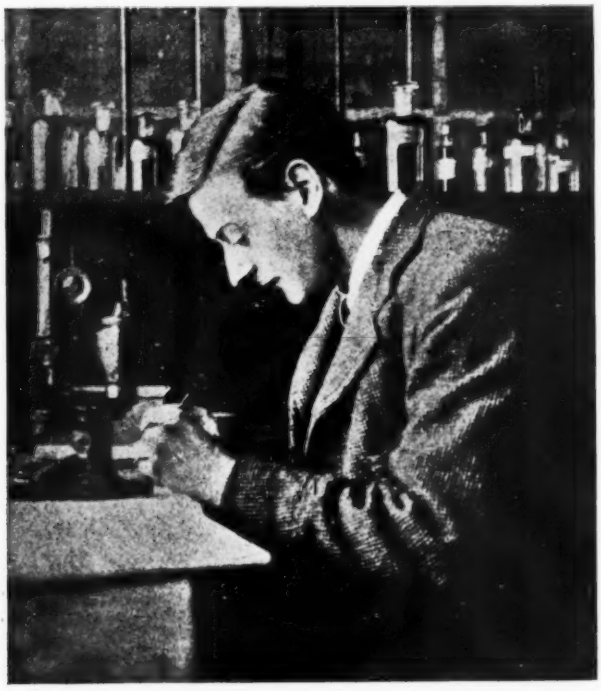
The initial discovery in his train of research was that a remarkable change in the primary and secondary sexual characters of the host crab was brought about by the presence of the parasite, *Sacculina*, but in the *male* host alone, which approximated more or less closely to the female type as a result of the

infection. This limitation had not been recognised by Giard and the changes in the female towards the male which the latter described were shown by Smith to be without significance. In a series of studies, on the Experimental Analysis of Sex, published in the *Quarterly Journal of Microscopical Science*, he developed his ideas on this phenomenon and employed all the methods he could learn to arrive at a right understanding of the relations between the parasite and the host. By 1913 he had made extensive biochemical studies of the changes in the crab, *Inachus*, for which *Sacculina* was responsible, and was laying the foundations of a chemical theory of sex. It was at this fruitful period of his career that his studies were interrupted and no other investigator has yet taken up the problems which his insight had discovered.

In spite of the fact that the monograph on Rhizocephala roused the disgust of Paul Mayer because its length did not reach the usual standard, it contained a great number of new and important observations besides those on the relation of host and parasite. His essays on parasitism were not however confined to this group. Just after the outbreak of war he published a paper on *Stylops* and stylopisation. His last published paper, a year later, was on the genus *Lernaeodiscus*. Protozoan parasites of crustacea and bacterial diseases of crayfish had also claimed his attention. In the last year before the war he commenced the study of Francesco Redi and those who knew his literary skill anticipated the keenest pleasure from his writings on this congenial subject.

This is not the place to dwell overmuch on his personality. But his simplicity, his humour and his charm, his modesty and his intellectual eminence combined to make him the most attractive figure among younger English zoologists. He had already inspired pupils with his own enthusiasm and if he could have been spared would have been the natural leader of a new school of English zoology.

Our portrait reproduces a photograph taken by Dr Shearer, F.R.S., and presented to the Molteno Institute by Mr Smith's family.



GEOFFREY WATKINS SMITH

1881—1916

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